# Circuit Court of the United States,

DISTRICT OF MASSACHUSETTS.

IN EQUITY.

No. 1424.

AMERICAN BELL TELEPHONE COMPANY ET AL.

*v.*

ALBERT SPENCER ET AL.

# Circuit Court of the United States,

SOUTHERN DISTRICT OF NEW YORK.

IN EQUITY.

AMERICAN BELL TELEPHONE COMPANY ET AL.

*v.*

ASAHEL K. EATON ET AL.

## PLEADINGS AND EVIDENCE.

CHAUNCEY SMITH, JAMES J. STORROW, } *for Complainants.*

FREDERIC H. BETTS, CHARLES W. WEST, } *for Defendants.*

BOSTON:
PRINTED UNDER DIRECTION OF THE CLERK.
1881.

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# Circuit Court of the United States,

DISTRICT OF MASSACHUSETTS.

IN EQUITY.

No. 1424.

AMERICAN BELL TELEPHONE COMPANY ET AL.

*v.*

ALBERT SPENCER ET AL.

## BILL OF COMPLAINT.

[FILED JULY 8, 1880.]

*To the Honorable the Justices of the Circuit Court of the United States, for the District of Massachusetts:*

The American Bell Telephone Company, and the Bell Telephone Company, corporations duly established under the laws of the Commonwealth of Massachusetts, bring this their bill of complaint against Enoch Waite, of Franklin, Norfolk County, Massachusetts, in said district, and Albert Spencer, of Providence, Rhode Island, carrying on business at Franklin, in said county. And thereupon your orators complain and say, that before the seventh day of March, 1876, Alexander Graham Bell, then of Salem, now of Boston, in said Commonwealth, being the original and first inventor of a new and useful improvement in telegraphy, which was never known or used before his invention thereof, and which had not at the time of his application been in public use or on sale for more than two years, made application according to law for Letters Patent of the United States, to be granted to him therefor; upon which application, due proceedings being had in all respects, said Letters Patent were on the seventh day of March, 1876, granted, issued and delivered to

said Alexander Graham Bell, signed by the Secretary of the Interior and countersigned by the Commissioner of Patents, and numbered 174,465, whereby there was secured to said Alexander Graham Bell, his heirs, administrators or assigns, for the term of seventeen years from the said seventh day of March, 1876, the full and exclusive right and liberty of making, constructing, using and vending to others to be used the said improvement, a description whereof is given in the words of the said Bell, in the schedule annexed to said patent, and forming a part thereof, as by said patent, numbered 174,465, or a copy thereof here in court to be produced, will fully appear.

That before the thirtieth day of January, 1877, the said Alexander Graham Bell, being the original and first inventor of another new and useful improvement in electric telegraphy, which was never known or used before his invention thereof, and which had not at the time of his application been in public use or on sale for more than two years, made application according to law for Letters Patent of the United States to be granted to him therefor; upon which application, due proceedings being had in all respects, said Letters Patent were, on the thirtieth day of January, 1877, granted, issued and delivered unto said Bell, signed by the Secretary of the Interior and countersigned by the Commissioner of Patents, and numbered 186,787, whereby there was secured to said Bell, his heirs, administrators or assigns, for the term of seventeen years from the said thirtieth day of January, 1877, the full and exclusive right and liberty of making, constructing, using and vending to others to be used the said improvement, the description whereof is given in the words of said Bell in the schedule annexed to said last-named patent, and forming a part thereof, as by said patent, numbered 186,787, or a copy thereof here in court to be produced, will fully appear.

That said Alexander Graham Bell assigned said Letters Patent, numbered respectively 174,465 and 186,787, to Gardiner G. Hubbard, trustee, by deed of assignment dated July 9, 1877, and recorded at the Patent Office, July 28, 1877, Liber R, 21, page 399 of Transfers of Patents. That said Gardiner G. Hubbard, trustee, assigned said Letters Patent, numbered respectively 174,465 and

186,787, to the Bell Telephone Company, by assignment dated July 20, 1878, and recorded at the Patent Office, Oct. 3, 1878, Liber Y, 22, page 460 of Transfers of Patents.

That said Bell Telephone Company has agreed to grant the same to your orator, the American Bell Telephone Company, and has authorized the American Bell Telephone Company to make and use telephones constructed under said patents, in the State of Massachusetts, and said American Bell Telephone Company is now engaged in the business of supplying electric speaking telephones and erecting telephone lines in said territory, for the use of which it receives a yearly royalty and license fee from its sub-licensees; and but for the unlawful acts of the defendants and their associates, hereinafter complained of, would be in the full and exclusive enjoyment of said right.

Your orators further show that after the grant of said Letters Patent, the inventions therein described and claimed, or substantial and material parts of same, embodied in instruments known as Bell telephones, and in instruments known as Blake transmitters, were introduced into public use by the said Bell, the said Hubbard, trustee, and your orators. That many thousands of persons have put the said inventions into daily use under the authority and license of the said Hubbard and your orators and their predecessors and those holding rights or licenses under them, and have paid for such use of said inventions the amount fixed by the owners of said patents as a reasonable compensation therefor, such payments amounting in the aggregate to many thousands of dollars. That the fact that said Bell was the original and first inventor of said inventions, and that the patents above named are good and valid patents, has been generally recognized and acknowledged by those who have used the inventions and the public generally, and the claims of the said Bell, Hubbard and your orators and their said predecessors to the exclusive right to the said inventions under said patents have been generally acknowledged and acquiesced in. That from time to time several persons have attempted to make, sell and use telephones, or parts thereof, embracing said inventions, but that in such cases said Hubbard while owner of, and your orators and their said predecessors since they

have owned said patents, have immediately, upon hearing of such acts or attempts, notified such parties to desist therefrom, and that such parties have generally, upon receiving such notices, complied therewith, and acquiesced in and recognized as valid the claims of said Hubbard and your orators under said patents; and said Bell, said Hubbard and your orators have always asserted and maintained, and but for the wrongful acts of the defendants would and have hitherto almost universally enjoyed the sole and exclusive right to practise said inventions; that they have not acquiesced in any infringement of their exclusive rights; and that the said exclusive rights of your orators are of great value to them.

That in the year 1878 Addison D. Hard, of Boston, electrician, infringed said Bell patents by making and selling telephones, or by making and selling the material and substantial parts thereof for the purpose of being put together and used as telephones; that thereupon the said Bell Telephone Company brought their bill in equity against him, in the Circuit Court of the United States for the District of Massachusetts; that an injunction was issued against him to desist from such infringement; and afterwards, and after hearing, the defendant was adjudged in contempt for violating said injunction, and was ordered to pay a sum of money into court, which sum was afterwards, to wit, Feb. 4, 1879, ordered to be paid, and was paid to said Bell Telephone Company.

That in the year 1878 one Jerome C. Redding also infringed said patents, and a bill in equity was brought against him in said court to restrain said infringement, and no defence was made, and an injunction issued, and said Redding desisted from further infringement.

That in the year 1878 one Jesse H. Bunnell, manufacturing electrician, did, in the city of New York, in like manner infringe said Bell patents; that thereupon the said Bell Telephone Company brought their bill in equity against him in the Circuit Court of the United States for the Southern District of New York; that he appeared thereto by counsel; that thereafter he submitted to the claims of the plaintiff; and that on the eighth day of February, 1879, an injunction was issued against him, restraining him from

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further infringement of said patents, and no further proceedings have been had in said cause.

And all said orders and decrees stand in full force and effect.

That the said exclusive rights of said Bell, and your orators and their predecessors as his assigns and grantees, have never been openly or publicly violated, except at one time, and in the year 1878, by the Western Union Telegraph Company, and by the Gold and Stock Telegraph Company, and by the American Speaking Telephone Company, said three corporations having associated themselves together for that purpose; that said Bell Telephone Company brought its bill in equity in the Circuit Court of the United States for the District of Massachusetts, against Peter A. Dowd, an agent of said associated companies, engaged in the business of using their infringing telephones, and in said suit complained of the defendant that he had infringed the fifth claim of said patent 174,465; and also complained that he had infringed the third, sixth, seventh and eighth claims of said patent 186,787; the said associated corporations assumed the defence of said suit, and employed in said defence their counsel and experts learned in the law and skilled in the art; in said suit evidence was taken and completed by the complainants in chief, and by the defendant in defence, and by the complainants in reply; and thereupon, upon consideration of said proof, and the opinions of their professional advisers, the defendant and said corporations became satisfied that said Bell was the true, original and first inventor of the electric speaking telephone, and the inventions covered by said patents; whereupon they submitted to the said claims of the complainants, and agreed to desist from further infringements, and have since desisted from further infringements, and placed and caused to be placed all telephones within their power or control under license under said Bell patents, and paid, or caused to be paid, the usual and customary yearly royalties therefor habitually charged by the assigns of said Bell to other parties for like uses, and agreed that they would not thereafter make electric speaking telephones, and would not thereafter use electric speaking telephones, except such as should be made and furnished to them by your orators or the assigns of said Bell, and under license under said Bell patents, and that for the use of the same they should

pay not less than the usual and accustomed royalties from time to time charged to others by your orators.

And your orators show that the telephones made by your orators and the infringing telephones of the defendants are small instruments, and easily concealed, and easily used in private, and easily transferred from one person to another, so that it is generally extremely difficult for your orators to detect all instances of such use, and extremely difficult to prove the use thereof by persons not licensed by your orators, and the extent of such use, and would be extremely onerous and burdensome for your orators to bring separate suits against each user to restrain said infringing use; and so, if the defendants, or any of them, shall be allowed to continue to manufacture and supply such instruments for use during the pendency of this suit, your orators will be wholly without adequate remedy in the premises.

Yet the defendants, well knowing the premises and the exclusive rights of your orators as aforesaid, but contriving to injure your orators and to deprive them of the benefit and advantage which might and otherwise would accrue to them from said inventions, without the license or consent of your orators, and in infringement of the said patents, as your orators are informed and believe, have made, sold and used telephones embracing the inventions secured to your orators in said Letters Patent, or substantial and material parts of them, and have used the several improvements secured to your orators by said patents, and are still using the said several improvements at Franklin and divers other places within said district, and have furnished electric speaking telephones made by it to a considerable number of persons within this district, to be connected up and used as electric speaking telephones for the transmission of articulate speech, by and according to the method secured to said Bell and to your orators by said patents, and still continue so to do; but precisely how long the defendants have made, sold and used the said several improvements, and to what extent they have made, sold and used them, your orators, for want of a discovery thereof, do not know and cannot set forth, and they pray that the defendants may be compelled to set forth the same in their answer.

And your orators have requested the said defendants to acknowl-

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edge their rights in the premises, and to desist and refrain from the said acts, and from disregarding and infringing your orators' said rights, and to account with and pay to your orators what is justly due to your orators by reason of said infringement.

But now so it is, may it please your Honors, that the defendants wholly refuse so to do; but on the contrary, continue and threaten to continue said infringement of the rights of your orators aforesaid, and particularly the said Albert Spencer threatens to make and put out other like instruments, and thereby cause irreparable injury to your orators' lawful business. All which is contrary to equity and good conscience.

To the end, therefore, that the said defendants may, if they can, show why your orators should not have the relief herein prayed, and may upon their oaths, and according to their best and utmost knowledge, remembrance, information or belief, full, true, direct and perfect answer make to all and singular the matters hereinbefore stated and charged, as fully and particularly as if the same were here repeated, and they especially interrogated as to each and every of said matters, and more especially may answer, discover and set forth, whether during any and what period of time, and whether at said Franklin or elsewhere, and when and where, they used said improvements, or either of them; and whether they manufactured or sold any electric speaking telephones or apparatus to transmit speech by electricity, or the various parts of such telephones, and how many they have made or sold, and to whom they have sold the same, and how the said telephone and the several parts of the same are constructed and used.

And your orators show that they are entitled to restrain all further use of telephones which have been or shall be manufactured and disposed of by the defendants or either of them, and to receive and collect from each user thereof a suitable sum as and for damages and profits in consequence of and growing out of such use by each person who has used the same; and not waiving said rights, but wholly insisting thereon, and asserting that they intend to pursue and enforce said rights against said users, your orators aver that the defendants are also liable to pay to your orators other sums as and for profits by them actually realized by and from said infringement and unlaw-

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ful acts. Wherefore your orators pray that the defendants may be decreed to account for and pay over to your orators all such gains and profits resulting to them from said infringements; and may be restrained, together with their servants and agents, by an injunction to be issued out of this honorable Court, or by one of your Honors, according to the law in such case provided, from making, selling or using the said improvements, patented as aforesaid, or either of them; and that they may also be enjoined and restrained as aforesaid during the pendency of this suit, and for such other and further relief in the premises as the nature of the case may require and to your Honors shall seem meet.

May it please your Honors to grant unto your orators, not only a writ of injunction, but also a writ of *subpœna*, to be directed to the said defendants and each of them, commanding them and each of them, at a certain time and under a certain penalty, therein to be limited, personally to be and appear before your Honors and this honorable Court, then and there to answer unto this bill of complaint, and to do and receive what to your Honors shall seem meet in the premises.

THE BELL TELEPHONE COMPANY,
W. H. FORBES, *President.*

THE AMERICAN BELL TELEPHONE COMPANY,
W. H. FORBES, *President.*

J. J. STORROW, *Solicitor and of Counsel.*
CHAUNCEY SMITH, *of Counsel.*

UNITED STATES OF AMERICA,
STATE OF MASSACHUSETTS,
SUFFOLK COUNTY, } ss.

JUNE 30, 1880.

Personally appeared William H. Forbes, above named, and having been duly sworn, doth depose and say, that he is president of said American Bell Telephone Company, and of said Bell Telephone Company; that he has read the foregoing bill and knows the contents thereof; that all the matters therein stated as to the acts of said corporations he knows to be true; that all other matters therein

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stated he believes to be true; and believes the said Bell to be the true, first and original inventor of the improvements in said two patents set forth and claimed.

Sworn to before me,

[SEAL] GEO. W. PIERCE, *Notary Public.*

---

# ANSWER OF ALBERT SPENCER.

[FILED SEPT. 6, 1880.]

*The Answer of the Defendant, Albert Spencer to the Bill of Complaint herein.*

This defendant, now and at all times hereafter saving and reserving unto himself all and all manner of benefit and advantage of exception that can or may be taken to the many errors, uncertainties and insufficiencies in the said bill of complaint contained, for answer thereto, or unto so much thereof as he is advised it is material or necessary for him to make answer unto, answering says: —

1. That he does not know and is not informed save by said bill whether or not either of said complainants is a corporation duly established as alleged in said bill, and he therefore denies the same, and leaves the complainants to make such proof thereof as they may be advised.

2. And this defendant, further answering, admits that Letters Patent of the United States, numbered 174,465, were on the seventh day of March, 1876, granted to Alexander Graham Bell, for an alleged new and useful improvement in telegraphy; but whether or not said Letters Patent were duly applied for or issued as stated in said bill, this defendant does not know and is not informed save by said bill, and he therefore denies the same, and leaves the complainants to make such proof thereof as they may be advised.

3. And this defendant, further answering, admits that Letters Patent of the United States, numbered 186,787, were on the thirtieth day of January, 1877, granted to said Bell for an alleged new and useful improvement in electric telegraphy; but whether or not

said Letters Patent were duly applied for or issued as stated in said bill, this defendant does not know and is not informed save by said bill, and he therefore denies the same, and leaves the complainants to make such proof thereof as they may be advised.

4. And this defendant, further answering, says that he does not know and is not informed save by said bill whether either of the assignments mentioned therein was made or recorded as alleged, or whether or not the agreement mentioned therein has been made, or the complainant, the American Bell Telephone Company, has received authority to make and use telephones as alleged in said bill, and he therefore denies the same, and leaves the complainants to make such proof thereof as they may be advised.

5. And this defendant, further answering, on information and belief avers that long before any invention by said Bell of the alleged improvement specified as his invention in said Letters Patent numbered 174,465, the same was known and used by the following persons at the following places, to wit: —

| By whom used. | Residence. | Where used or known. |
|---|---|---|
| Elisha Gray | Highland Park, Ill. | Oberlin and Cleveland, Ohio, Highland Park and Chicago, Ill., and New York City. |
| Thomas A. Edison | Menlo Park, N. J. | Menlo Park, N.J., and New York City. |
| Amos E. Dolbear | Somerville, Mass. | Somerville, Mass. |
| Alfred G. Holcomb | Granby, Conn. | New York City, N. Y. |
| Philip H. Vanderweyde | New York City, N. Y. | New York City, N. Y. |
| W. F. Channing | Providence, R. I. | Providence, R. I. |
| Benjamin F. Edmands, Deceased. | | Boston, Mass., Washington, D. C., and New York City. |
| James Hamblet, Jr. | Brooklyn, N. Y. | Boston, Mass., Washington, D. C , and New York City. |
| Asahel K. Eaton | Brooklyn, N. Y. | Brooklyn, N. Y. |
| Edward Farran | Keene, N. H. | Keene, N. H. |
| Antonio Mencci | Clifton, Staten Island. | Staten Island and New York City. |
| Charles Bourseul | France. | France. |
| Phil. Reis | Friedrichsdorf, Germany. | Friedrichsdorf and Frankfort, Germany. |
| W. S. Voelker | Morton, Delaware Co., Pa. | Philadelphia, Pa., Morton, Delaware Co., Pa., and other places. |
| John H. Irwin | Morton, Pa. | Philadelphia and Morton, Penn. |

And also by numerous other parties whose names and residences are now unknown to this defendant, but which, when known, this defendant prays leave by proper amendments to insert in this answer.

6. And this defendant, further answering, alleges on information and belief that long prior to any invention by said Bell of the alleged

improvement specified as his invention in said Letters Patent numbered 174,465, the same was described in and patented by the following Letters Patent, viz.: Letters Patent granted by the United States in the year 1873, to Thomas A. Edison and George Harrington, dated Aug. 12, 1873, numbered 141,777; Letters Patent granted by the United States to William Thompson, in the year 1874, dated Nov. 17, 1874, numbered 156,897; Letters Patent granted by the government of Great Britain, in the year 1840, to Charles Wheatstone, dated Jan. 21, 1840, numbered 8,345; and also other Letters Patent which are now unknown to this defendant, but which, when known, this defendant prays leave by proper amendments to insert in this answer.

7. And this defendant, further answering, alleges on information and belief that long before any invention by said Bell of the alleged improvement specified as his invention in said Letters Patent numbered 174,465, the same was described in the following printed publications, viz.: —

"Electricity and Magnetism," by —— Jenkins, published in London, England, and in the city of New York, in the year 1873, at page 334. "Der Elektromagnetische Telegraph," by H. Schellen, published in Brunswick, Germany, in the year 1867, at pages 468 and 469. "The Electric Telegraph," by R. Sabine, published in London, England, in the year 1867, at pages 45 and 46. "The Electric Telegraph," by Dr. Lardner new edition, revised by E. B. Bright, published in said London, in the year 1867, at pages 164-165, 166 and 167. "Die Neueren Apparate der Akustik, von Dr. Prof. Fr. Jos. Pisko, Wien, 1865." "L'Eco d'Italia, 1860." "Lehr buch der Technischen Physik," by Dr. Hessler-Pisko, published at Vienna, 1866, Vol. I., page 648. And also in a printed publication in the German language, entitled "Jahres-Bericht des Physikalischen Vereins, zu Frankfurt am Main," printed and published in 1862, particularly at pages 57 to 64. A printed publication in the German language, entitled "Zeitschrift des Deutch-Oesterreichischen Telegraphen-Vereins," Vol. IX., printed and published in 1862, particularly at pages 125 to 130. A printed publication in the German language, entitled "Die Neueren Apparate der Akustik, von Dr. Prof. Fr. Jos. Pisko," printed and published in 1865, particularly at pages 96 to

103. And also other printed publications which are now unknown to this defendant, but which, when known, this defendant prays leave by proper amendments to insert in this answer.

8. And this defendant, further answering, says that he is advised and avers that the specification of said Letters Patent numbered 174,465 does not sufficiently describe the things attempted to be covered by the claims thereof to enable persons skilled in the art or science to which it appertains, or with which it is most nearly connected, to make, construct and use the same, and that the alleged improvements attempted to be patented in the said Letters Patent did not involve or require invention, and did not differ in any patentable respect from what was before said alleged invention known and used in this country or described in patents and printed publications.

9. And this defendant, further answering, on information and belief denies that said Bell was the original and first inventor of the alleged improvements specified as his invention in said Letters Patent numbered 186,787, and avers that long prior to any invention thereof by him, the same was known to and used by the following persons at the following places, to wit:—

| By whom used. | Residence. | Where used or known. |
|---|---|---|
| Elisha Gray | Highland Park, Ill. | Oberlin and Cleveland, Ohio, Highland Park and Chicago, Ill., and New York City. |
| Thomas A. Edison | Menlo Park, N. J. | Menlo Park, N. J., and New York City. |
| Amos E. Dolbear | Somerville, Mass. | Somerville, Mass. |
| Alfred G. Holcomb | Granby, Conn. | New York City, N. Y. |
| Phil. H. Vanderweyde | New York City, N. Y. | New York City, N. Y. |
| W. F. Channing | Providence, R. I. | Providence, R. I. |
| U. S. Telephone Co. | Pittsburg, Pa. | Pittsburg, Pa. |
| Geo. A. Hamilton | Elizabeth, N. J. | Pittsburg, Pa. |
| Asahel K. Eaton | Brooklyn, N. Y. | Brooklyn, N. Y. |
| Edward Farran | Keene, N. H. | Keene, N. H. |
| Antonio Mencci | Clifton, Staten Island. | Staten Island and New York City. |
| Charles Bourseul | France. | France. |
| Phil. Reis | Friedrichsdorf, Germany. | Friedrichsdorf and Frankfort, Germany. |
| W. S. Voelker | Morton, Delaware Co. Pa. | Philadelphia, Pa., Morton, Delaware Co., Pa., and other places. |
| John H. Irwin | Morton, Pa. | Philadelphia and Morton, Pa. |

And also by numerous other persons whose names and residences are now unknown to this defendant, but which, when known, this defendant prays leave by proper amendments to insert in this answer.

10. And this defendant, further answering, on information and

belief avers that long before any invention by said Bell of the alleged improvement specified as his invention in said Letters Patent numbered 186,787, the same was described in and patented by the following Letters Patent, viz. : Letters Patent granted by the government of Great Britain, in the year 1874, to J. H. Johnson, dated July 29, 1874, and numbered 2,646; Letters Patent granted by the Patent Office of the Dominion of Canada, in the year 1875, to Elisha Gray, dated July 7, 1875, numbered 4,749; Letters Patent granted by the United States, in the year 1875, to Elisha Gray, dated July 27, 1875, numbered 166,095; Letters Patent granted by the United States in the year 1876, to Elisha Gray, dated April 11, 1876, numbered 175,971; and also other Letters Patent which are now unknown to this defendant, but which, when known, this defendant prays leave by proper amendments to insert in this answer.

11. And this defendant, further answering, on information and belief avers that long before any invention by the said Bell of the alleged improvement specified as his invention in said Letters Patent numbered 186,787, the same was described in the following printed publications, viz. : —

"Der Elektromagnetische Telegraph," by Dr. H. Schellen, published at Brunswick, Germany, in the year 1867, at pages 411, 412, 413, 414, 429, 430, 431, 432, 433, 434, 435, 436, 437, 438, 468 and 469. "Zeitschrift des Deutsch-Osterreichischen Telegraphen-Verein," published at Berlin, Prussia, in the year 1862, Vol. IX., at page 25. "The Electric Telegraph," by R. Sabine, published in London, England, in the year 1867, at pages 136, 137 and 138. "The Telegraphic Journal," published in said London, in the year 1872, Vol. I., at page 4. "Electricity," by R. M. Ferguson, published in said London, and Edinburgh, Scotland, in the year 1867, at pages 257 and 258. "The Telegrapher," published in said city of New York, in the year 1869, Vol. V., No. 39, at page . "The Manufacturer and Builder," published in said city of New York, in the year 1869, Vol. I., at page 129. "Wonders of Electricity," by J. Bailes, published in said city of New York, in the year 1872, at pages 140, 141, 142 and 143. "The Telegraphic Journal," published at said London, in the year 1875, Vol. III., at pages 286, 287 and 288. "Die Neueren Apparate der Akustik,

von Dr. Prof. Fr. Jos. Pisko Wien, 1865. "L' Eco d' Italia," 1860. "Lehrbuch der Technischen Physik," by Dr. Hessler-Pisko, published at Vienna, 1866, Vol. I., page 648. And also in other printed publications which are now unknown to this defendant, but which, when known, this defendant prays leave by proper amendments to insert in this answer.

12. And this defendant, further answering, says that he is advised and avers that the specification of said Letters Patent numbered 186,787 does not sufficiently describe the thing attempted to be covered by the claims thereof to enable persons skilled in the art or science to which it appertains, or with which it is most nearly connected, to make, construct and use the same, and that the alleged improvements attempted to be patented in the said Letters Patent did not involve or require invention, and did not differ in any patentable respect from what was before said alleged invention known and used in this country, or described in patents and printed publications.

13. And this defendant, further answering, on information and belief says that there is no mechanical combination between the elements constituting the sixth claim of said Letters Patent, numbered 186,-787, and that no invention was required to produce the same.

14. And this defendant, further answering, says that he is not informed save by said bill whether or not instruments known as Bell telephones and instruments known as Blake transmitters have been introduced into public use, as alleged in said bill, and whether or not parties have been notified to desist from making, selling or using telephones as alleged in said bill, and he leaves the complainants to make such proof thereof as they may be advised.

15. And this defendant, further answering, says that he is not informed save by said bill whether or not the decrees and orders mentioned in said bill of complaint were obtained as alleged therein, and he leaves the complainants to make such proof thereof as they may be advised; but this defendant on information and belief avers that there has been no final adjudication or decree upon the merits, sustaining the validity of the patents in the bill of complaint mentioned.

16. And this defendant, further answering, denies that the

assumed rights of said Bell have never been publicly or openly violated, with exceptions alleged in said bill; and as to the suit pending against Peter A. Dowd, mentioned in said bill, this defendant on information and belief avers that said suit is still pending, and no final adjudication has been obtained therein, but that merely a temporary settlement has been made therein, which in no way admits the validity of the patents granted to said Bell, and numbered respectively 174,465 and 186,787.

17. And this defendant, further answering, denies that at the town of Franklin or elsewhere he has at any time unlawfully and wrongfully made or caused to be made, used or caused to be used, sold or caused to be sold, telephones embracing and containing the invention and improvements, or any of them, set forth and described in said Letters Patent numbered 147,465 and 186,787, or that this defendant has infringed any exclusive rights or privileges of or vested in the complainants whatever, or that he has inflicted any damages upon the said complainants, or that he has realized any gains or profits by means of such alleged infringements.

18. And this defendant prays the same benefit of the facts and things herein set forth as if for reason thereof he had demurred to said bill where a demurrer would have been proper, and the same benefit thereof as if he had specially pleaded to the said bill where a special plea would have been proper.

19. Therefore this defendant denies the equity of said complainants' bill, and that the complainants are entitled to the relief in said bill prayed, or any part thereof; without this, that any other matter, cause or thing in said bill contained, material or necessary for the defendant to make answer unto, and not hereinbefore sufficiently answered, confessed, traversed, denied or avoided, is true, to the knowledge or belief of this defendant.

Wherefore this defendant prays that he may be hence dismissed with his costs and charges in this behalf most wrongfully sustained.

ALBERT SPENCER.

EDMUND WETMORE,
*Solicitor for Defendant* ALBERT SPENCER, *and of Counsel.*

STATE OF RHODE ISLAND, }
COUNTY OF PROVIDENCE, } ss.

Albert Spencer, being duly sworn, says that the foregoing answer is true of his own knowledge, except as to the matters therein stated on information and belief, and that as to those matters he believes it to be true.

Subscribed and sworn before me this fourth day of September, 1880.

CHAS. E. SCOTT, *Notary Public.*

[SEAL]

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## REPLICATION.

[FILED SEPT. 30, 1880.]

*The Replication of the Bell Telephone Company and the American Bell Telephone Company, Plaintiffs, to the Answer of Albert Spencer, Defendant.*

These repliants, saving and reserving unto themselves all and all manner of advantage of exception to the manifest insufficiencies of the said answer, for replication thereunto say: —

That they will aver and prove their said bill to be true, certain and sufficient in the law to be answered unto, and that the said answer of the defendant is uncertain, untrue and insufficient to be replied unto by these repliants; without this, that any other matter or thing whatever in the said answer contained, material or effectual in the law to be replied unto, confessed and avoided, traversed or denied, is true. All which matters and things these repliants are and will be ready to aver and prove as this honorable Court shall direct, and humbly pray as in and by their said bill they have already prayed.

*By their Attorneys,*

CHAUNCEY SMITH.
J. J. STORROW.

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# Circuit Court of the United States,

DISTRICT OF MASSACHUSETTS.

IN EQUITY.

No. 1424.

AMERICAN BELL TELEPHONE COMPANY ET AL.

*v.*

ALBERT SPENCER ET AL.

# Circuit Court of the United States,

SOUTHERN DISTRICT OF NEW YORK.

IN EQUITY.

AMERICAN BELL TELEPHONE COMPANY ET AL.

*v.*

ASAHEL K. EATON ET AL.

## EVIDENCE FOR COMPLAINANTS.

TAKEN PURSUANT TO THE SIXTY-SEVENTH RULE OF THE SUPREME COURT OF THE UNITED STATES, IN EQUITY, AS AMENDED, BEFORE ME,

CHARLES H. SWAN, *Examiner.*

BOSTON, Jan. 27, 1881.

Present: CHAUNCEY SMITH, Esq., *of Counsel for Complainants;* FREDERIC H. BETIS, Esq., *of Counsel, and* CHARLES W. WEST, *Solicitor for Defendant* SPENCER *in Massachusetts suit; and for Defendants,* EATON, TOMPKINS, *and* EATON TELEPHONE COMPANY, *in New York suit.*

STATE OF RHODE ISLAND, }
COUNTY OF PROVIDENCE, } ss.

Albert Spencer, being duly sworn, says that the foregoing answer is true of his own knowledge, except as to the matters therein stated on information and belief, and that as to those matters he believes it to be true.

Subscribed and sworn before me this fourth day of September, 1880.

CHAS. E. SCOTT, *Notary Public.*

[SEAL]

---

## REPLICATION.

[FILED SEPT. 30, 1880.]

*The Replication of the Bell Telephone Company and the American Bell Telephone Company, Plaintiffs, to the Answer of Albert Spencer, Defendant.*

These repliants, saving and reserving unto themselves all and all manner of advantage of exception to the manifest insufficiencies of the said answer, for replication thereunto say: —

That they will aver and prove their said bill to be true, certain and sufficient in the law to be answered unto, and that the said answer of the defendant is uncertain, untrue and insufficient to be replied unto by these repliants; without this, that any other matter or thing whatever in the said answer contained, material or effectual in the law to be replied unto, confessed and avoided, traversed or denied, is true. All which matters and things these repliants are and will be ready to aver and prove as this honorable Court shall direct, and humbly pray as in and by their said bill they have already prayed.

*By their Attorneys,*

CHAUNCEY SMITH.
J. J. STORROW.

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# Circuit Court of the United States,

DISTRICT OF MASSACHUSETTS.

IN EQUITY.

No. 1424.

AMERICAN BELL TELEPHONE COMPANY ET AL.

*v.*

ALBERT SPENCER ET AL.

# Circuit Court of the United States,

SOUTHERN DISTRICT OF NEW YORK.

IN EQUITY.

AMERICAN BELL TELEPHONE COMPANY ET AL.

*v.*

ASAHEL K. EATON ET AL.

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CHARLES H. SWAN, *Examiner.*

BOSTON, Jan. 27, 1881.

Present: CHAUNCEY SMITH, Esq., *of Counsel for Complainants;* FREDERIC H. BETTS, Esq., *of Counsel, and* CHARLES W. WEST, *Solicitor for Defendant* SPENCER *in Massachusetts suit; and for Defendants,* EATON, TOMPKINS, *and* EATON TELEPHONE COMPANY, *in New York suit.*

It is hereby stipulated that all evidence taken and exhibits offered in evidence, and all stipulations made by either party in either of the cases of American Bell Telephone Co. *v.* Spencer, or American Bell Telephone Co. *v.* Eaton, in the Southern District of New York, shall be considered as taken and offered in evidence in the other also of said cases.

Plaintiffs offer in evidence a certified copy of Letters Patent of the United States granted Alexander Graham Bell, March 7, 1876, No. 174,465, and marked "Exhibit Bell Patent No. 174,465."

Also a certified copy of Letters Patent of the United States granted Alexander Graham Bell, dated Jan. 30, 1877, No. 186,787, and marked "Exhibit Bell Patent No. 186,787."

Plaintiffs further offer in evidence a certified copy of an assignment from Alexander Graham Bell to Gardiner G. Hubbard, dated July, 1877.

Also a certified copy of an assignment from Gardiner G. Hubbard to the Bell Telephone Company, dated July 20, 1878.

Also a certified copy of an assignment from Bell Telephone Company to American Bell Telephone Company, dated June 22, 1880.

Also a copy of a deed of license Bell Telephone Company to American Bell Telephone Company, dated July 6, 1880, marked "Exhibit Assignments."

Defendants' counsel and solicitor admit the execution of said instruments offered as exhibits; and waive proof of the organization and incorporation of the above-mentioned companies.

Plaintiffs offer in evidence an instrument marked "Complainants' Exhibit Eaton Magneto Telephone."

Also an instrument marked "Complainants' Exhibit Eaton Battery Transmitter."

It is admitted that the defendant company, and A. K. Eaton, as its employé, made and sold, prior to the filing of the bill, instruments like those introduced above in evidence, to be used for transmitting speech over an electric circuit in which they are included, by speaking to the instrument marked "Exhibit Battery Transmitter," and listening to the one marked "Eaton Magneto Telephone"; and that said company has issued the circular now offered in evidence, and marked "Eaton Telephone Company's Circular."

It is admitted that the defendant, Spencer, sold, prior to the filing

of the bill, instruments like those introduced above in evidence, to be used for transmitting speech over an electric circuit in which they are included, by speaking to the instrument marked "Exhibit Battery Transmitter," and listening to the one marked "Eaton Magneto Telephone."

Attest: CHAS. H. SWAN, *Examiner.*

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## DEPOSITION OF CHARLES R. CROSS.

*Direct Examination by* CHAUNCEY SMITH, Esq., *of Counsel for Complainants.*

BOSTON, Jan. 27, 1881.

*Int.* 1. State your name, age, residence, and occupation.

*Ans.* Charles R. Cross; I am thirty-two years old; I live in Boston, and am Thayer Professor of Physics in the Massachusetts Institute of Technology.

*Int.* 2. State how long and to what extent you have been engaged in the study of the physical sciences; and to what extent, if at all, you have been accustomed to make experiments in the several branches of physics, especially those relating to electricity and acoustics.

*Ans.* I have been an instructor at the Institute of Technology during the past ten years, and during that time I have been constantly engaged in the study of various branches of physics. During the past eight years I have especially investigated the subjects of acoustics and certain branches of electricity. In the prosecution of my studies during this time I have constantly been engaged in the experimental study of the subjects mentioned, and have been practically familiar with all the apparatus ordinarily used by scientific men in the investigation of sound and electricity.

*Int.* 3. What attention have you given to the speaking telephone and to its principles and mode of operation?

*Ans.* I have been familiar with the rise and development of the speaking telephone from its very beginning, having been in frequent communication with Professor Bell ever since the winter of 1873–4. I am familiar with Mr. Bell's patents, have investigated with great care the theory upon which these patents are based; and am practically familiar with the construction and use of the various forms of

instruments constructed in accordance with said patents. During the past two years, I have conducted a very extensive series of experiments relating to the different branches of telephony, in the capacity of expert for the Bell Telephone Company.

*Int.* 4. State whether or not you have testified as a witness in any cases in the courts of the United States upon the principles of the invention embodied in patents, and in machines or apparatus.

*Ans.* I have done so frequently.

*Int.* 5. You say you have been familiar with Mr. Bell's patents. State whether or not among these patents are those which have been introduced in evidence in this case marked "Exhibit Bell Patent No. 174,465," and "Exhibit Bell Patent No. 186,787."

*Ans.* The patents No. 174,467 and No. 186,787 are among those which I have had frequent occasion to examine.

*Int.* 6. Referring to the patent No. 174,465, will you explain the mode of operation of the apparatus referred to in the fifth claim of the patent; explaining, as far as may be necessary, the character of sounds, their action upon the apparatus, and the manner in which the apparatus operates to produce the results which are ascribed to it in the patent?

*Ans.* The sensation of sound is produced by the action upon the ear of the vibrating particles of air which are set into a vibratory, or to-and-fro motion, by the vibrations of the sounding body. The primary impulse given by the sounding body to those particles of air immediately in contact with it, is gradually transmitted from particle to particle, in consequence of the elasticity of the air, or other medium through which the sound passes. In consequence of the mode of action of the elasticity of the air, the motion originally communicated to the particles of air in contact with the sounding body, is not transferred instantaneously to all the other particles; but in consequence of their *inertia*, as the sounding body vibrates to and fro, a similar movement is impressed upon one after the other of the particles surrounding it. This to-and-fro motion of the vibrating body generates a similar minute to-and-fro motion of the air particles, so that they are alternately crowded more closely together, and separated more widely from each other, thus producing alternate condensations and rarefactions in the air. It is to these alternate condensations and rarefactions

that the term "sound-wave" is given. It will be observed that each particle vibrates to and fro in a straight line in the direction in which the wave motion is propagated. If we consider that the vibration of the air particles is produced immediately by the vibration of the sounding body, we see that the motions of the air particles must be a perfect copy of the motions of the particles of the vibrating body. Such vibrations may differ in three separate ways, viz., in the extent of the path of the vibrating particle, in the frequency of its vibration, and in the character of its vibration. It is evident, in the first place, that the vibrating particle may, in its to-and-fro motion, traverse a longer or shorter path; in the second place, it may traverse this path a greater or less number of times in each second, that is, its rate of vibration may differ; in the third place, while traversing its path it may move according to different laws of acceleration or retardation of its velocity: for example, its acceleration during a part of its course may be, and in some cases is constant, or the rate of acceleration may constantly change, and the law of its change may vary in different ways. To the changes in motion thus caused, what I have called the peculiar character of the vibration is due. If we consider these three kinds of variation, in their effect upon the senses, we find that variations in the extent of the path or amplitude of vibration of the particle determine, other things being the same, the loudness of the sound; the variations in the frequency of vibration determine the pitch of the sound; and variations in the character of the vibration determine what is known as the quality, or *timbre*, of the sound.

In the statements which I have just made I have spoken of the motion of a single particle; but it is evident, from the mode of transmission of sound, that all of the particles of the air through which the sound is conveyed partake of the various characteristics of vibration which I have discussed.

I have used the term "quality or *timbre*"; quality is that peculiarity of a sound by which, independently of its pitch or loudness, we are enabled to determine the instrument by which the sound is produced; thus, for example, the note of a violin differs from the note of a flute in quality, even though the two are the same in pitch and loudness.

It is well known to scientific men that these differences in quality, which, as I have said, are due to differences in the character of the motions of the vibrating particle, are produced acoustically by the combination of a number of separate or partial tones, which can be shown to be produced when a particle is in vibration; and which partial tones differ in number, in pitch and in intensity or loudness, in accordance with differences in the character of the motion of the vibrating air particles.

The lowest of these partial tones is called the "fundamental," the other and higher notes "overtones." Hence it is evident that the quality of a sound depends upon the relative pitch, intensity and number of partial tones present. In a very few exceptional cases only the fundamental is present, and what is called a simple sound is produced. In general, the pitch of a note is determined by the fundamental, the overtones determining the quality. These facts, constituting what is known as Helmholtz's Theory of Quality, were first discovered by the physicist whose name the theory bears. The human voice owes its peculiar quality to the presence of great numbers of these partial tones; and very slight changes in the partial tones will produce very considerable changes in the voice.

From what I have said thus far, it will be seen, that in order to reproduce articulate speech, we must be able to reproduce, in the air, vibrations which shall possess all these characteristics of pitch, intensity and quality; and which shall, moreover, possess those same characteristics of pitch, intensity and quality; that is, of rate of vibration, amplitude of vibration, and character of vibration, which are possessed by the vibrating particles which are set in vibration directly by the organs of speech. If we can determine the speed and direction of motion of an air particle at each instant, and hence, also, the extent of its path, we can evidently impress upon it all three of the characteristics that I have mentioned; and hence can produce any desired sound at will.

In Mr. Bell's patent No. 174,465, a method is described by which the motions which are produced in the air at one place, the transmitting station, can be reproduced by an electrical method of intercommunication at the receiving station. By means of his invention he is able, by the use of certain electrical apparatus, to impress upon the

particles of air at a distant place, the receiving station, motions substantially identical with those which are immediately impressed by the voice upon the particles of air at the transmitting station.

According to the specification, he effects this result by the use of the transmitter, which takes up from the air at the transmitting station the motions which are impressed upon it by the voice of the speaker, and the vibrating portion of which transmitter moves in substantial accordance with the movements of the air particles themselves. This transmitter, being connected with a line wire joining the two stations between which speech is to be transmitted, is enabled, by its electrical connection with that wire, to produce in it electrical variations which correspond to and are similar in form to the motions of the movable part of the transmitter, and hence to the motions of the air particles which have actuated the movable part of the transmitter. These electrical variations, in their turn, set in motion a movable part of a receiving instrument with which the line wire is connected, and in their turn produce in this movable part of the receiver vibrations corresponding to and similar in form to those electrical vibrations by which they are produced, and hence to the motions of the air particles at the transmitting station. The movable part of the receiving instrument, thus vibrating, impresses upon the air at the receiving station vibrations similar in form and corresponding to its own motions.

The motions thus produced in the air particles at the receiving station are therefore evidently similar in form, and correspondent to the original vibrations impressed upon the air at the transmitting station by the voice of the speaker at that station. This being the case, it is evident, from what I have said, that the sound uttered by the speaker at the transmitting station will be reproduced at the receiving station.

It appears from these facts that Mr. Bell's apparatus consists essentially of a transmitter adapted to take up the vibrations of the air at the transmitting station; a line wire connecting the transmitting with the receiving station, together with a battery or some other form of electrical apparatus, which is capable of furnishing a supply of electricity; which line wire shall serve to transmit the electrical variations produced by the transmitter from one station to the other; and a receiver which, actuated by the electrical variations

thus transmitted by the line wire, shall be caused to reproduce the motions of the transmitter and of the air particles by which that transmitter is actuated. It is true that the receiving instrument may not always reproduce the vibrations of the air particles at the transmitting station in every minute detail, but the instrument is a speaking telephone only so far as it is adapted to reproduce those motions with substantial fidelity; and its practical construction and reproduction must be such that these vibrations shall be substantially reproduced.

It is evident that when the transmitter is in operation, variations in the electrical current may take place in three ways, — there may be a variation in either the direction of the current; the rate or violence of change of the current; and the frequency of change of the current: and from these three kinds of variations similiar variations in the direction, rate and frequency of change of the motion of the movable part of the receiver will result. And hence, from these different electrical variations, differences in the quality, intensity and pitch of the sound produced by the receiving instrument will follow. Therefore, to reproduce articulate speech or any other sound in all its characters of pitch, intensity and quality, it is necessary that the movable portion of the receiving instrument should be constantly under the guidance of, and controlled by, the movable portion of the transmitting instrument; and in case this constant control is not exercised, and in precisely that degree in which it ceases to be exercised, the instrument becomes incapable of transmitting articulate speech.

No form of transmitter which operates by making and breaking an electrical circuit can possibly transmit articulate speech, or any other sound in its different characteristics of pitch, intensity and quality; for the reason that the constant control of which I have spoken is not exercised in such an instrument. With any circuit-breaking instrument the loudness and quality of the sound produced at the receiving station are dependent solely upon the physical construction and action of the receiving instrument itself, and of the battery or other source of electricity by which the transmitter is acted upon. The intensity and quality of the sound produced at the

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receiving station are therefore, with such an instrument, entirely independent of the intensity and quality of the original sound produced at the transmitting station. It is for this reason that an instrument of this class, such as, for example, the well-known Reis instrument, is incapable of transmitting either intensity or quality; and hence is incapable of transmitting articulate speech.

As will be seen from what I have already said, the Reis transmitter, or any other transmitter which operates by making and breaking the circuit, is capable of transmitting pitch, and pitch only.

There is also another reason which prevents a Reis transmitter, or other circuit-breaking instrument, from transmitting articulated speech; this is the effect of the interruptions of the current, in producing a loud and disagreeable noise in the receiver, which, of itself, would be sufficient to overpower and obliterate those fine shades of variation upon which differences in quality depend.

In fact this noise is so marked, that an ordinary battery transmitter can be used as a telephonic call by so operating it as to cause it to actually make and break the electrical circuit. Under these circumstances, the noise which proceeds from the receiving instrument, which, when the transmitter is used in a normal and proper manner, can be heard only by one close to the instrument, is capable of being heard throughout a large room.

*Int.* 7. You speak of the sound waves, and explain the mode in which they are produced. Do you understand that the actual existence of these sound waves has been demonstrated, or is accepted as a fact by scientific men?

*Ans.* The existence of such sound waves has been accepted as a fact by scientific men for several hundred years. Within a few years past, they have been visibly shown to exist by a method which demonstrates the existence of alternate condensations and rarefactions to the eye.

*Int.* 8. Has any method of representing such waves been adopted; and if so, what is it?

*Ans.* It is customary among physicists to represent the motions of the particles of a sound wave, and also the variations in condensation and rarefaction at different points in a sound wave by a graph-

thus transmitted by the line wire, shall be caused to reproduce the motions of the transmitter and of the air particles by which that transmitter is actuated. It is true that the receiving instrument may not always reproduce the vibrations of the air particles at the transmitting station in every minute detail, but the instrument is a speaking telephone only so far as it is adapted to reproduce those motions with substantial fidelity; and its practical construction and reproduction must be such that these vibrations shall be substantially reproduced.

It is evident that when the transmitter is in operation, variations in the electrical current may take place in three ways, — there may be a variation in either the direction of the current; the rate or violence of change of the current; and the frequency of change of the current: and from these three kinds of variations similiar variations in the direction, rate and frequency of change of the motion of the movable part of the receiver will result. And hence, from these different electrical variations, differences in the quality, intensity and pitch of the sound produced by the receiving instrument will follow. Therefore, to reproduce articulate speech or any other sound in all its characters of pitch, intensity and quality, it is necessary that the movable portion of the receiving instrument should be constantly under the guidance of, and controlled by, the movable portion of the transmitting instrument; and in case this constant control is not exercised, and in precisely that degree in which it ceases to be exercised, the instrument becomes incapable of transmitting articulate speech.

No form of transmitter which operates by making and breaking an electrical circuit can possibly transmit articulate speech, or any other sound in its different characteristics of pitch, intensity and quality; for the reason that the constant control of which I have spoken is not exercised in such an instrument. With any circuit-breaking instrument the loudness and quality of the sound produced at the receiving station are dependent solely upon the physical construction and action of the receiving instrument itself, and of the battery or other source of electricity by which the transmitter is acted upon. The intensity and quality of the sound produced at the

3934

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There is also another reason which prevents a Reis transmitter, or other circuit-breaking instrument, from transmitting articulated speech; this is the effect of the interruptions of the current, in producing a loud and disagreeable noise in the receiver, which, of itself, would be sufficient to overpower and obliterate those fine shades of variation upon which differences in quality depend.

In fact this noise is so marked, that an ordinary battery transmitter can be used as a telephonic call by so operating it as to cause it to actually make and break the electrical circuit. Under these circumstances, the noise which proceeds from the receiving instrument, which, when the transmitter is used in a normal and proper manner, can be heard only by one close to the instrument, is capable of being heard throughout a large room.

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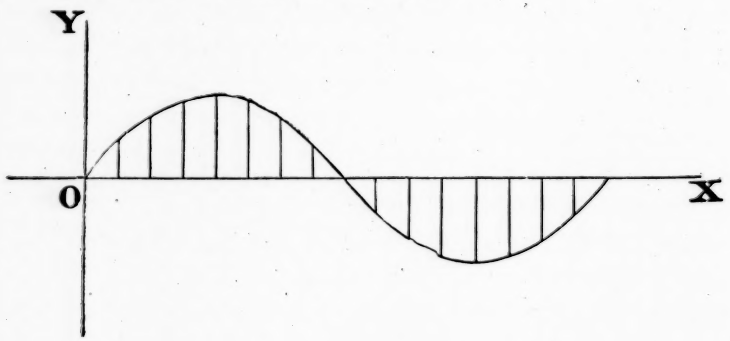
*Ans.* The existence of such sound waves has been accepted as a fact by scientific men for several hundred years. Within a few years past, they have been visibly shown to exist by a method which demonstrates the existence of alternate condensations and rarefactions to the eye.

*Int.* 8. Has any method of representing such waves been adopted; and if so, what is it?

*Ans.* It is customary among physicists to represent the motions of the particles of a sound wave, and also the variations in condensation and rarefaction at different points in a sound wave by a graph-

ical method. I can best illustrate this by reference to a diagram which I produce, to be incorporated in my answer.




The curve in the diaphragm is what is called a sinusoidal curve, such as corresponds to the sound waves produced by a simple sound, consisting of a single note without overtones. (Such a sound can be produced by a tuning-fork, mounted on a resonant case, and bowed in a manner suitable for this purpose.) O X is divided into a number of equal spaces to represent equal periods of time. The length of these spaces is purely arbitrary. The distances from O to the beginning of any one of these divisions are called *abscissas*. From each of these points on O X, representing successive intervals of time, lines are drawn parallel to O Y, and proportional in their relative lengths to the distances of the particle from the point of rest at the successive periods of time. In the case of the particle pursuing a simple vibration, these magnitudes will increase to a maximum which will be attained at the instant when it reaches the extremity of its path; they will then diminish, as it comes back to the starting point; and as it passes beyond it, moving in the other direction, they will be indicated by distances measured off below the line O X. Joining then the extremities of the perpendicular lines, we obtain a broken line somewhat resembling a curve; and if we put the perpendicular lines close enough together, the broken line joining their extremities becomes a curve. This curve is determined by the length of two sets of lines or distances, — the *abscissas* measured on O X, and the *ordinates* measured parallel to O Y. In the case stated, the

starting point is assumed to be in the middle of the path (*e. g.*, the position of a pendulum when at rest), and the motion is measured in both directions from it; *i. e.*, the curve is on both sides of the line, and part of the ordinates have one direction, part the other. But the point from which the measurements are taken is purely arbitrary; and the line O X, which represents this point, might be placed lower down and tangent to the lowest part of the curve. In that case the curve would not change its character, but the ordinates would all be measured in one direction and on one side of O X. Algebraically expressed, they would all be + quantities, instead of being alternately + and — quantities in the two branches of the curve; only the + quantities would be greater than shown in the diagram. In the case indicated by the diagram we should consider that an increase in the length of the ordinates, in passing from one to the next, signified motion in one direction, and a decrease signified motion in the other direction. In this method of representation one set of lines, measured along O X, corresponds to the period in which the movement is executed, or its frequency; and the other, measured along O Y, to the amplitude or extent and also to the direction of the motion; and these measurements express frequency, amplitude and direction. The same curve will represent the extent of rarefaction and of condensation of the air produced by the movement of the particles, and also, when correctly interpreted, the motion and the varying velocity of the particles.

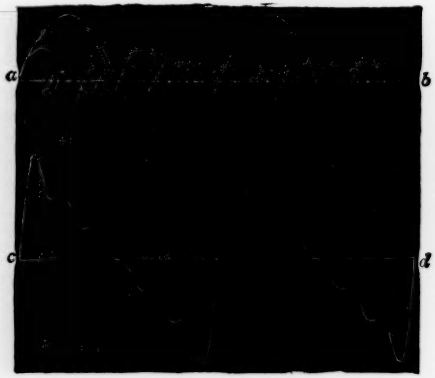
It is from this habit of graphical expression that a vibration is commonly spoken of among physicists as having "form"; form of vibration is a phrase used to signify the "character" of a vibration, as I have explained it.

It must be remembered that this curve does not represent the path of the moving particle; that always moves to and fro in a straight line. This curve is merely a convenient form of expressing to the eye the character and variation of the motion.

*Int.* 9. If you can produce from any scientific work a diagram representing the manner in which overtones are combined with a fundamental to give quality to sound different from that due to the fundamental alone, and representing the form given to the curve as the result of all the vibrations, will you do so, stating the source

from which you derive it, and explaining, as far as you think necessary, the diagram?

*Ans.* The following diagram, taken from Mayer on "Sound," p. 153, represents the motion of a particle under the influence of sound waves: —



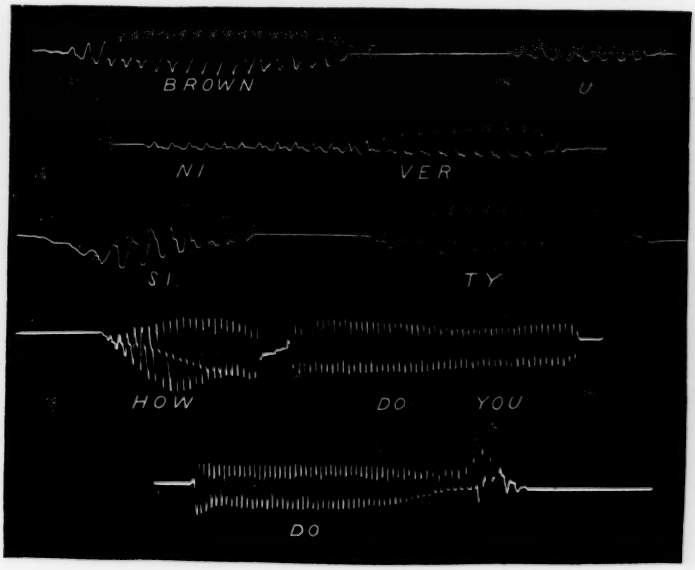

The curves at *a b* represent six sound waves of six simple sounds. When these are sounded together as fundamental and overtones, and with relative intensities corresponding to the amplitude of the curves, as drawn, so as to produce a sound having the quality due to this combination, the vibrational "form," as it is called, of the sound perceived by the ear is represented by the curve at *c d*. The set of vibrations which constitutes one complete vibration is shown twice between *c* and *d*. The entire "form" or character of this curve can be determined and controlled, as already stated, by determining or controlling for each point the length of the abscissa and of the ordinate for that point, or in other words, determining or controlling the elements of time or frequency, amplitude or intensity, and direction; but it is obvious that it will require very many measurements of abscissas and ordinates to determine or control the "form" of each complete set of vibrations.

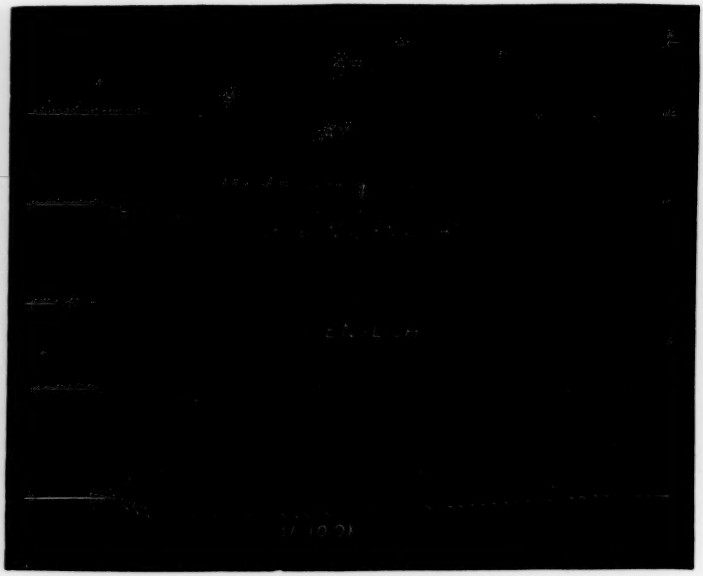
The curve representing one set of vibrations is about three inches long; and it is apparent, even to a casual observer, that by taking the ordinates as little as one eighth of an inch apart, we should miss the little twists which most strikingly represent to the eye the "qual-

ity" or the effect of the overtones in this vibrational form, and which are equally important to the "quality" of the sound as perceived by the ear; and as in the articulate speech of a woman there are twenty-four thousand of these *complete* sets in a minute, it will be obvious that in order to reproduce this vibration the control must be exercised not merely twenty-four thousand times a minute, but really without any interruption or cessation whatever.

*Int.* 10. If observations have been made upon the curves produced by spoken words, and you can produce a diagram representing the results of such observations, will you do so, giving the authority from which they were made?

*Ans.* The minute changes which take place during articulation are well shown in a series of curves made by Prof. E. W. Blake, Jr., of Brown University, and described in "Silliman's Journal" for July, 1878. These curves were produced by reflecting a ray of light from a mirror, so attached to the plate of a speaking telephone that the vibrations of this plate were communicated to the mirror. The reflected ray is caused to act photographically upon a sensitized plate of glass, the mirror at the same time being caused





to vibrate by the action of the voice upon the telephone plate. On rapidly moving the plate of glass in a direction at right angles to that in which the reflected ray was caused to vibrate by the vibrations of the mirror, a photographed representation of the complex vibrations of the mirror was produced. In Prof. Blake's figures the vibrations characteristic of different vowels, and the rapidly changing vibrations produced in the case of a spoken sentence, are very beautifully shown. According to the statement made by Prof. Blake in the article referred to, the vibrations are magnified in the accompanying cuts one hundred and twelve times. Notwithstanding the accuracy of Prof. Blake's drawings, the mere thickness of the lines in the wood-cut is sufficient to obliterate many of the more delicate variations in those vibrations which characterize articulate speech.

*Int.* 11. Referring again to the first Bell patent (No. 174,465) to which your attention has been called, will you state what the moving parts are which you have referred to as being put in motion by sound waves or by variations of current produced by sound waves?

*Ans.* In Fig. 7 the transmitter possesses a movable armature, *c*, one end of which is hinged, while the other is so attached to a membrane at *a* that when this membrane is set in vibration by the utterance of a sound into the cone A, the armature shall be caused to take up the vibrations of the membrane. By the vibration of this armature, as it approaches nearer to or recedes from the pole of the electro-magnet *b*, in accordance with the well-known laws of magneto-electric induction, electrical undulations or waves are produced in and transmitted by the line wire *e*. The receiving instrument which is in electrical connection with the line wire possesses an electro-magnet, *f*, whose magnetic strength varies in accordance with the electrical variations produced in the line wire, in the manner described. In front of this electro-magnet of the receiver and opposite its pole is a vibratory armature of inductive metal hinged at *k* and connected at *i* with a membrane stretched over the larger end of the cone L, so that variations in the magnetic strength of the electro-magnet *f*, produced by electrical variations in the line wire *e*, produce vibrations in the armature *h*, and consequently in the attached membrane, so that this attached membrane vibrates in correspondence with the motions of the membrane of the transmitting instrument, and therefore in correspondence with the vibrations of a voice by which the membrane of the transmitter is actuated. I should have said that the vibrating armatures of both the transmitting and receiving instruments are of iron or other inductive metal; and I would also call attention to the fact that the hinged end of each of these vibratory armatures is in magnetic connection with that pole of the electro-magnet which is farthest from the vibrating part of the armature itself; this mode of connection serving to increase to a certain degree the magnetic strength of the apparatus.

[*Adjourned.*]

JAN. 28.

*Int.* 12. Will you explain a little more in detail the function of the battery represented in Fig. 7 of the Bell patent of which you have been speaking, and the manner in which the undulations in the current are produced in the apparatus represented in that figure; and in what way the undulatory current acts in the receiving instrument to produce the proper results?

*Ans.* The magnets *b* and *f* in Fig. 7 are electro-magnets having soft iron cores, which cores are magnetic only when a current of electricity is passing through the coils surrounding them. The object of the battery shown in Fig. 7 is simply to produce this current, which shall cause the cores to be kept magnetized. The armature *c* of the transmitter, which is of iron or other inductive metal, will, as it moves to and fro, alternately increase and diminish the magnetic strength of the magnet *b*. These variations of magnetic strength will correspond to the various changes in motion of the vibrating armature. In accordance with the well-known laws of magneto-induction, as discovered by Faraday, every change in the magnetic strength of the core of the electric magnet *b* will produce corresponding changes in the current of electricity which passes through the line wire *e*. These variations in the strength of the current will cause corresponding variations in the magnetic strength of the electro-magnet *f*, and these variations in the strength of the magnet will act immediately upon the vibratory armature at *h*. An increase of strength in the magnet *f* will cause the armature to approach to the magnet, while diminution of magnetic strength will allow the armature, under the influence of the tension of the membrane to which it is attached, to recede farther from the pole *f*. Hence, under the influence of the varying magnetic strength of *f*, the vibratory armature at *h* will execute vibrations corresponding to these changes in magnetic strength, and therefore corresponding to the changes in the electric current in the line wire *e*, to the changes in the magnetic strength of the magnet *b*, and therefore corresponding to the variations in the motion of the vibratory armature at *c*, when moved by the vibrations of the membrane with which it is in contact. The membrane of the receiving instrument at *i* will therefore vibrate in correspondence with the membrane *a* of the transmitting instrument.

*Int.* 13. Do you find any method suggested in the patent as an alternative one to that you have described for producing the variations or undulations in the current between the transmitter and receiver; if so, will you quote from the specification the language which refers to such other mode?

*Ans.* It was well known to electricians, long before the date of Mr. Bell's first patent, that the strength of electrical current can be

varied, either by increasing its electro-motive force, or by diminishing the resistance of the circuit, in accordance with the well-known law of Ohm, $\text{Current} = \frac{\text{Electromotive force}}{\text{Resistance.}}$

In the apparatus which I have described, Mr. Bell explains a method of producing these electrical undulations by varying the electro-motive force of the current. He also clearly recognizes the possibility of producing such undulations by varying the resistance of the circuit. In his specification, No. 174,465, I find the following: —

"Electrical undulations may also be caused by alternately increasing and diminishing the resistance of the circuit. . . . The internal resistance of a battery is diminished by bringing the voltaic elements nearer together, and increased by placing them farther apart. The reciprocal vibration of the elements of a battery, therefore, occasions an undulatory action in the voltaic current. The external resistance may also be varied. For instance, let mercury or some other liquid form part of a voltaic circuit; then the more deeply the conducting wire is immersed in the mercury or other liquid, the less resistance does the liquid offer to the passage of the current. Hence the vibration of the conducting wire in mercury or other liquid included in the circuit, occasions undulations in the current. The vertical vibrations of the elements of a battery in the liquid in which they are immersed, produce an undulatory action in the current, by alternately increasing and diminishing the power of the battery."

*Int.* 14. If electricians have been in the habit of stating the law to which you have referred in algebraic terms, will you give the form of expression which has been used, explaining the symbols; and state how long that law has been known, and whether or not it is one which has been found of use in the practical application of electricity?

*Ans.* The law of Ohm is usually expressed by a formula $C = \frac{E}{R}$, in which C is the strength of the current, E, the electro-motive force, that is the force producing the current; and R, the total resistance of the circuit. Ohm's law was, if I recollect rightly, first stated by him about the year 1830. For the last thirty years its importance has been fully recognized by physicists, and it has been applied by constructors of electrical apparatus in determining the dimensions and arrangement of the different parts of such apparatus.

*Int.* 15. State whether or not, in your judgment, the substitution

*Ans.* The magnets *b* and *f* in Fig. 7 are electro-magnets having soft iron cores, which cores are magnetic only when a current of electricity is passing through the coils surrounding them. The object of the battery shown in Fig. 7 is simply to produce this current, which shall cause the cores to be kept magnetized. The armature *c* of the transmitter, which is of iron or other inductive metal, will, as it moves to and fro, alternately increase and diminish the magnetic strength of the magnet *b*. These variations of magnetic strength will correspond to the various changes in motion of the vibrating armature. In accordance with the well-known laws of magneto-induction, as discovered by Faraday, every change in the magnetic strength of the core of the electric magnet *b* will produce corresponding changes in the current of electricity which passes through the line wire *e*. These variations in the strength of the current will cause corresponding variations in the magnetic strength of the electro-magnet *f*, and these variations in the strength of the magnet will act immediately upon the vibratory armature at *h*. An increase of strength in the magnet *f* will cause the armature to approach to the magnet, while diminution of magnetic strength will allow the armature, under the influence of the tension of the membrane to which it is attached, to recede farther from the pole *f*. Hence, under the influence of the varying magnetic strength of *f*, the vibratory armature at *h* will execute vibrations corresponding to these changes in magnetic strength, and therefore corresponding to the changes in the electric current in the line wire *e*, to the changes in the magnetic strength of the magnet *b*, and therefore corresponding to the variations in the motion of the vibratory armature at *c*, when moved by the vibrations of the membrane with which it is in contact. The membrane of the receiving instrument at *i* will therefore vibrate in correspondence with the membrane *a* of the transmitting instrument.

*Int.* 13. Do you find any method suggested in the patent as an alternative one to that you have described for producing the variations or undulations in the current between the transmitter and receiver; if so, will you quote from the specification the language which refers to such other mode?

*Ans.* It was well known to electricians, long before the date of Mr. Bell's first patent, that the strength of electrical current can be

varied, either by increasing its electro-motive force, or by diminishing the resistance of the circuit, in accordance with the well-known law of Ohm, $\text{Current} = \frac{\text{Electromotive force}}{\text{Resistance.}}$

In the apparatus which I have described, Mr. Bell explains a method of producing these electrical undulations by varying the electro-motive force of the current. He also clearly recognizes the possibility of producing such undulations by varying the resistance of the circuit. In his specification, No. 174,465, I find the following: —

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*Int.* 14. If electricians have been in the habit of stating the law to which you have referred in algebraic terms, will you give the form of expression which has been used, explaining the symbols; and state how long that law has been known, and whether or not it is one which has been found of use in the practical application of electricity?

*Ans.* The law of Ohm is usually expressed by a formula $C = \frac{E}{R}$, in which C is the strength of the current, E, the electro-motive force, that is the force producing the current; and R, the total resistance of the circuit. Ohm's law was, if I recollect rightly, first stated by him about the year 1830. For the last thirty years its importance has been fully recognized by physicists, and it has been applied by constructors of electrical apparatus in determining the dimensions and arrangement of the different parts of such apparatus.

*Int.* 15. State whether or not, in your judgment, the substitution

of one of these ways of varying the current for the other, changes substantially the character of the described apparatus as an apparatus for transmitting sounds; or changes substantially the method by which sounds are transmitted or reproduced.

[*Objected to by counsel for defendants as incompetent, on the ground that the question involves, in part, a question of law and a legal construction of the patent of Bell.*]

*Ans.* Speaking as a scientific man, I should say that it does not.

*Int.* 16. If you have examined the two instruments which have been produced in evidence, marked respectively Exhibits "Eaton Battery Transmitter" and "Eaton Magneto Telephone," and find them adapted to be used for any purpose when connected in electrical circuit with a battery, state what you find their purpose to be.

*Ans.* I find that the instruments referred to are, from their construction and method of operation, adapted, when suitably connected with a battery, to transmit articulate speech.

*Int.* 17. State whether or not, in your judgment, when so connected and used for that purpose, they constitute an apparatus substantially like that described in the Bell patent of which you have been speaking, and referred to in the fifth claim, and which will operate in transmitting sounds by substantially the same method; and whether or not, in your judgment, they embody, when so used, the invention described in said patent and referred to in said claim?

[*Same objection as to Int.* 15.]

*Ans.* The apparatus to which I have referred in my last answer, Exhibits "Eaton Battery Transmitter" and "Eaton Magneto Telephone," when connected and so operated as to transmit articulate speech, use the method invented by Mr. Bell, and described in his specification No. 174,465, for transmitting vocal or other sounds telegraphically, by causing electrical undulations similar in form to the vibrations of the air accompanying such sound. The instruments in question most certainly embody the invention which Mr. Bell describes in his specification referred to; and when used in the transmission of articulate speech, constitute an apparatus which is substantially that described by Prof. Bell.

*Int.* 18. Will you compare these instruments, when so connected and used, with Mr. Bell's apparatus to which you have referred,

pointing out the functions and mode of operation of the several parts; and if you find that these instruments differ specifically from the Bell apparatus, explain the nature of the differences, and give your judgment as to their affecting the substantial likeness of this apparatus to the Bell apparatus, and its method of operation.

*Ans.* In Mr. Bell's patent No. 174,465, I find a transmitting instrument, a receiving instrument, a line wire connecting these and a battery or other source of electricity. In the apparatus described the transmitter possesses a movable part which is capabable of being set in vibration by the agency of the voice. This movable part is so arranged that it shall cause electrical variations in the current traversing the line wire. The receiver is so arranged that the variations of current referred to shall communicate motion to a movable part, which shall in its turn communicate motion to the air about it. As I have already shown, at some length, the vibrations of this movable portion, when actuated by the sound waves produced by the voice, correspond to these in form; and by their action upon the receiving instrument cause it to vibrate in a similar manner, and hence produce corresponding vibrations in the air about the receiver. The function of the transmitter, it is evident, is simply to produce in the line wire electrical undulations similar in form to the vibrations of the air particles through whose agency they are produced. The function of the receiver is simply to translate, so to speak, the electrical undulations produced by the transmitting instrument and conveyed to the receiving instrument by the line wire, into vibrations of the air at the receiving instrument. Mr. Bell indicates that these electrical undulations may be produced either by varying the electromotive force of the current, or by varying the resistance of the circuit.

In the exhibits specified I find a transmitter and a receiver, which, when placed in electrical connection with each other by means of a line wire, and provided with a battery as a source of electricity, are adapted to transmit, and will transmit articulate speech from one station to another.

In the Eaton battery transmitter, I find an instrument which, from its construction, is adapted to produce, and when properly operated by the voice, will produce electrical undulations in the cur-

rent traversing the circuit, similar in form to the air waves by which these electrical variations are produced.

In the Eaton receiver, I find an instrument which is adapted to produce vibrations in the air, similar in form to vibrations originally produced in the air, at the transmitting station, by the voice; as I have already explained. The Eaton apparatus, like the Bell apparatus, contains a transmitter, which from its construction is adapted to produce electrical undulations as described, and a receiver which is adapted to retranslate these electrical undulations into vibrations of the air.

The Eaton battery tran-mitter adopts one of the methods mentioned by Mr. Bell, as suitable for the production of electrical undulations similar in form to the air waves produced by the voice; namely, by varying the resistance of the circuit. The precise method adopted in the Eaton transmitter for varying the resistance of the circuit is different from the particular method referred to by Mr. Bell, inasmuch as it utilizes the property of variation in resistance with variation in pressure possessed by various substances.

In my opinion, however, the adoption of one rather than another particular method of varying the resistance of the circuit does not materially affect the substantial likeness of the apparatus of Mr. Bell and Mr. Eaton, or its method of operation.

*Int.* 19. Will you state whether the fact to which you refer, that the resistance of substances may be varied by pressure, was one known before the date of Mr. Bell's patent, and recognized in the construction of electrial apparatus; and if you can refer to any electrial works of authority, where this fact is referred to, will you do so, and quote the references to the fact?

*Ans.* It was known long before the date of Mr. Bell's patent, that the resistance of a circuit is varied, without being broken, by variations in the intimacy of contact or amount of pressure between two electrodes in contact, from one to the other of which a current is passing. This fact was noted and recorded by Du Moncel in his book, "Applications de l'Electricité," Vol. II., page 246, edition of 1856, published at Paris in that year. In "Comptes Rendus," for July, 1874, a communication from the same writer described some experiments as to the resistance offered to the current in passing

from one electrode to another, in the case where one was a good conductor and the other a poor conductor, and showed that a moderate increase of pressure at the contacts would materially increase the conductivity and thereby the current; and he gave his explanation for this phenomenon.

In Du Moncel, "Applications de l'Electricité," ed. 1856, Vol. I., p. 246, I find the following: —

"Une chose assez curieuse, et qui paraît être au premier abord en contradiction avec la théorie que l'on s'est faite de l'électricité, c'est que la plus ou moins grande pression exercée entre les pièces de contact des interrupteurs influe considérablement sur l'intensité du courant qui les traverse. Cela tient souvent à ce que les métaux de l'interrupteur ne sont pas toujours dans un état parfait de décapage au point de contact, mais peut-être aussi à une cause physique encore mal appréciée. Ce qui est certain, c'est que, dans les interrupteurs où la pièce mobile de contact est sollicitée par une force extrêmement minime, le courant éprouve souvent des affaiblissements assez notables pour faire manquer la réaction électrique qu'on attend d'eux."

Which I translate as follows: —

"A somewhat curious fact, which at first sight appears to be in contradiction to the views ordinarily received as to the action of electricity, is that the greater or less pressure exercised between the contact pieces of interrupters has an important influence upon the strength of the current which traverses them. This often happens because the metal of the interrupter is not perfectly free from rust at the point of contact, but perhaps also because of a physical cause as yet but little appreciated. This is certain, that with interrupters in which a movable contact piece is acted upon by a very slight pressure, the current often sustained such an enfeeblement as to cause a failure in the electrical action which was expected."

The same writer describes, in "Comptes Rendus" for July 6, 1874, a series of experiments in which he measured the current in a circuit, part of which consisted of a platinum electrode and a piece of wood, more or less damp, kept in constant contact, but with varying pressure and says, page 41, in an article entitled "Récherches sur les transmissions electriques a travers les corps ligneux," as follows: —

"Les expériences que j'avais à faire pour avoir une constatation exacte des effets produits, étaient assez delicates, car une foule de

causes étrangères peuvent intervenir, et changer les résultats fournis. Ainsi le dégré de serrage des plaques metalliques de communication avec le bois, sur isolement plus ou moins parfait du sol et des murs de l'appartement, où l'on expérimente, la grandeur des surfaces mises en communication avec le circuit métallique, la masse du bois, l'état plus ou moins humide de l'air des expériences, le contact fortuit des doigts sur les fils de communication avec le galvananetre, et l'état d'isolement de ces fils sont autant de causes qui peuvent modifier les résultats que l'on obtient.

. . . . . .

"6. Que le dégré de la pression de la plaque de platiné contre le bois a tellement influé sur l'intensité du courant ainsi transmis, qu' étant de 12 dégrés avec un serrage maximum elle est devenue à zéro quand la plaque était abandonné a son propre poids, et a 5 dégrés seulement avec un faible serrage."

This I translate as follows: —

"The experiments that I have had to make in order to have an exact proof of the effects produced were very delicate, because a number of foreign elements might enter and change the results. Thus *the amount of pressure upon the metallic plates in communication with the wood* is more or less perfect insulation from the earth or the walls of the room, the size of the surfaces put in communication with the metallic circuit, the mass of the wood, the greater or less humidity of the air, the accidental contact of the fingers with the wires leading to the galvanometer, and the condition of the insulation of these wires were causes which might modify the results that would be obtained.

. . . . . .

"6. That the amount of the pressure of the platinum plate against the wood has so much influence on the strength of the current thus transmitted, that from twelve degrees, with a maximum pressure, it became reduced to zero when the plate was pressed only by its own weight, and to five degrees only with a slight pressure."

In Du Moncel's "Traité de Telegraphie Electrique," Paris, 1864, Part IV., page 559, in speaking of apparatus designed to establish electrical contact, the author says, "L'expérience montre que plus la pression des contacts est grande, plus est énergique l'intensité du courant qui les traverse," that is, in English, "Experiment shows that the greater the pressure of the contact pieces, the stronger is the current passing through them."

This fact was also constantly acted upon in the practical use of

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electrical apparatus; care was always taken that contacts should be firm and with considerable pressure, for otherwise the full and desired strength of current was not obtained.

*Int.* 20. In the Exhibit Eaton Magneto Telephone the magnet, as I understand it, is a permanent magnet and differs somewhat in form from the electro-magnet shown in the Bell receiver. State whether or not these differences affect the substantial likeness of the two instruments in respect to their function and mode of operation, and the work they do in the transmission of sounds.

*Ans.* They do not, since the function of the battery represented in Fig. 7, of Mr. Bell's specification, is merely to keep the cores of the electro-magnets magnetic. When permanent magnets are employed the permanent magnetism of such magnets is substituted for the magnetization produced by the battery current.

*Int.* 21. Will you refer to the second Bell patent, No. 186,787, which has been produced in evidence, and describe briefly so much of the apparatus therein described as is referred to in the fifth, sixth and eighth claims, pointing out the functions or results which are attributed to the parts of the apparatus referred to in those claims?

*Ans.* Claim 5 relates to the special form of magnet suited for use in an electric telephone; the coil being placed about the end or ends of the magnet nearest the plate. The object of thus placing the coil is to render the magnet quicker in its working, that is, more ready to respond with the requisite rapidity to the variations in the strength of the current passing through the coil. A magnet with the coil thus placed responds more quickly by changes in its strength to slight changes in the strength of the current, and hence it is better adapted for use in the speaking telephone than a magnet in which the coil surrounds the whole length of the magnet, and which consequently acts more slowly.

In claim 6 is mentioned the sounding box, which is combined with the telephone. This sounding box has an important influence in screening the plate of the instrument from the effect of extraneous sounds. The thin air space in front of the plate also exercises an important influence.

In claim 8 I find mentioned the combination of a permanent magnet, with coils upon its end or ends, as described, with

a plate of iron or other material, capable of inductive action. The use of the plate of iron, in connection with the magnet, as described in a system of electric telephony, furnishes a most excellent method of causing the electrical and magnetic variations of the apparatus to produce corresponding vibrations in the air.

*Int.* 22. Referring to the defendants' instruments which have been introduced in evidence, will you compare them with the apparatus described in the patent last referred to, and state how far, if at all, you find them to embrace the features or combinations described in the patent and referred to in the claims above specified?

*Ans.* In the defendants' magneto-telephone, I find a magnet with a coil upon the end nearest the plate, as described in claim 5. This magnet is placed within a sounding box, as described in claim 6. I find, also, the combination of a permanent magnet with a plate of iron as described in claim 8. The mouthpieces of both instruments are so arranged as to leave a thin space filled with air in front of the vibrating plate.

*Int.* 23. Do you find in Eaton's battery trasmitter that the diaphragm is protected from the action of extraneous sounds by a box substantially like that described in the Bell patent?

*Ans.* I do find that it is thus protected.

*Int.* 24. I find, in the second Bell patent, a statement that the same instrument is used both as a transmitter and a receiver; and I understand that the electrical portion of the apparatus described in Bell's first patent is the same both in the transmitter and receiver. Will you state whether the exhibit marked "Eaton Magneto Telephone" is, when properly connected in line with another instrument of the same kind, capable of being used as a transmitter as well as a receiver?

[*Objected to as immaterial and as not relating to any issue in this case.*]

*Ans.* It is.

*Int.* 25. You referred, I believe, to the fact that in the Eaton battery transmitter the reduced space is present, shown in front of the plate in Bell's second patent. State whether or not you also find in that transmitter the reduced orifice which admits the sound waves to the plate directly at its centre.

*Ans.* I do.

*Cross Examination by* F. H. BETTS, Esq., *of Counsel for Defendants.*

*Cross-Int.* 26. In your answer to Int. 3 you spoke of yourself as acting in the capacity of expert for the Bell Telephone Company. Will you please to state precisely what your relations to the complainant company are?

*Ans.* I have no relations with the complainant company except as they have employed me from time to time to try various experiments and undertake various tests for them, and also frequently to testify concerning these experiments and concerning various scientific facts relating to the subject of telephony.

*Cross-Int.* 27. In your sixth answer you gave evidence tending to explain the mode of operation of the apparatus which you say is referred to in the fifth claim of Bell's patent, No. 174,465. Please state whether you find delineated in the drawings of said Bell patent any apparatus which is capable of transmitting either vocal or other sounds telegraphically, by causing electrical undulations similar in form to the vibrations of the air accompanying such sounds, except only the apparatus shown in Fig. 7 of said patent.

*Ans.* Fig. 7 of said patent shows a form of apparatus of wide, general adaptation for the transmission of such sounds. Fig. 5, however, represents an apparatus adapted to transmit certain sounds telegraphically.

*Cross-Int.* 28. In your opinion, is the apparatus shown in Fig. 5, and described in the descriptive portion of the specification which refers to Fig. 5, an apparatus which fulfils the conditions recited in the fifth claim of said Bell patent in any degree?

*Ans.* As I indicated in my answer to the previous question, the apparatus represented in Fig. 5 is limited in its adaptation to transmitting certain kinds of sounds only; and although in its use the method of transmitting sound by causing electrical undulations similar in form to the vibrations of such sounds is used, yet it is not properly an apparatus intended to transmit vocal sounds or sounds in general, until modified in certain ways. It is not furnished with the necessary parts to enable the transmitter to take up the sound of the air readily on the one hand, or the receiver to readily set the air

in vibration at the other. These necessary additions are found in the apparatus represented in Fig. 7.

*Cross-Int.* 29. In your last answer you say that the apparatus shown in Fig. 5 is not properly an apparatus "intended" to transmit vocal sounds; and that certain additions are necessary to enable the transmitter and receiver there shown to act "readily." I wish to know whether in your opinion the apparatus shown in Fig. 5 is capable, in any degree, of transmitting vocal sounds according to the method referred to in said fifth claim?

*Ans.* I am not willing to give an opinion on this subject unless it is based upon careful and thorough experimentation to determine the point in question. I have not made any experiments which will enable me to answer the question.

*Cross-Int.* 30. Will you not please give such opinion upon the point as you can give at the present time, from the knowledge and experience which you have up to this present time acquired?

*Ans.* As will be seen from my previous answers, I do not consider the apparatus in Fig. 5 well adapted to transmit vocal sounds telegraphically. I cannot say, however, in the absence of sufficient experiment, whether it is or is not possible to transmit vocal sounds to a certain extent.

*Cross-Int.* 31. You referred to the fact that the first Bell patent describes a mode of varying resistance in the line, by letting mercury or some other liquid form part of the voltaic circuit, so that the extent to which the conducting wire is immersed in the liquid is proportioned to the resistance offered to the passage of the current. In your opinion, is a telephone in which the resistance is varied in that mode a practically useful form of instrument?

*Ans.* Other forms of transmitter using this same principle in a different manner have proved more convenient and efficient than this earliest form of battery transmitter. It is very likely for this reason that it has never been perfected with care, and hence is not practically used. The use of the liquid is, of course, to a certain extent, a practical disadvantage.

*Cross-Int.* 32. You have referred to the fact in your eighteenth answer, that in the defendants' instrument marked "Eaton Battery Transmitter," the varying of the resistance of the circuit is effected

by utilizing the property of variation in resistance possessed by various substances with variation in pressure. Do you regard the adaptation of that property to use in the telephone as an important and valuable invention?

*Ans.* I do.

*Cross-Int.* 33. From your knowledge of the progress of the art in the invention and improvement of the telephone, to whom do you attribute the introduction of that invention?

*Ans.* The principle in question was used very early by Mr. Berliner, and this is the earliest application of the principle in question to telephony with which I am acquainted. It was afterwards used by a German inventor, by Mr. Edison, Mr. Blake, and others.

*Cross-Int.* 34. Is the patent of Mr. Emile Berliner, No. 199,141, dated Jan. 15, 1878, application filed Oct. 16, 1877, the earliest record which you know of, which shows the above invention in telephony?

*Ans.* It is the earliest record of any action which unquestionably involves the principle of the microphone. I have not the date of the invention of Mr. Edison's original battery telephone, which also uses variations in the resistance of a carbon disk under varying pressure. The date of Edison's patent No. 203,016, is April 30, 1878.

*Cross-Int.* 35. Is the Eaton battery telephone an instrument of the same class as those described in the Berliner patent, dated Jan. 15, 1878, and the Edison patent, dated April 30, 1878, above referred to?

*Ans.* It is.

*Cross-Int.* 36. In your last answer you have spoken of the "microphone." What do you understand to be the essential features of the microphone?

*Ans.* Two conducting surfaces in contact with each other, of such nature that variations in pressure caused by sound shall produce corresponding variations in resistance, and connected in electrical circuit.

*Cross-Int.* 37. Are the surfaces of all conducting materials of such a nature that variations in the pressure caused by sound will cause corresponding variations in resistance, when such materials are connected in electrical circuit? And if not, state what substances or materials have this property.

*Ans.* I do not know whether all substances do or do not possess this property. It is, however, possessed by many substances, especially by carbon, iron, brass and many metallic oxides.

*Cross-Int.* 38. Is it possessed by platinum?

*Ans.* Platinum, apparently, possesses this property only in a slight degree. It should be remembered, however, in considering this question, that the amount of change of resistance which is produced by a given pressure is an entirely different thing from the variation of the resistance of the joint in correspondence with the variations in pressure.

*Cross-Int.* 39. Please explain your last answer a little more fully.

*Ans.* We might have, for example, one substance in which a slight variation in pressure caused a very great variation in resistance, but in which the variation in resistance did not correspond at all in magnitude with the variation in pressure. Or on the other hand, we might have a substance in which considerable increase of pressure caused but very slight change in the resistance, but which change in resistance, although very minute, yet varied in direct proportion to the variation in pressure.

*Cross-Int.* 40. In order to make a telephone in which the resistance in the circuit was varied by variations in pressure, was it not necessary to discover a substance in which the variations in resistance, under varying pressure, corresponded in magnitude with such variations in pressure?

*Ans.* It was.

*Cross-Int.* 41. Who first made that discovery, as you understand the history of the art of telephony?

*Ans.* I cannot say with certainty, as there have been many claimants.

*Cross-Int.* 42. What is the earliest record of it that you know of?

*Ans.* Du Moncel, in his work on the telephone, refers to experiments of his own, some of which date back to 1856, and also to an apparatus of M. Clarac, in 1865. I have not attempted to investigate the question of priority so far as these earlier experiments are concerned.

*Cross-Int.* 43. What I wished to know was, who made the discovery referred to in Cross-Int. 40, as a practical one in the art of telephony, and what was the earliest record of that?

*Ans.* Mr. Berliner; a German whose name I have forgotten; and Mr. Edison; early utilized the principle. A more definite statement than this I do not feel ready to make, without looking at the matter with this particular end in view; more especially as the date of the patent does not show the date of the original experiments.

*Cross-Int.* 44. In your opinion, does the microphone, as described and illustrated on page 165 of Du Moncel's work on the microphone and phonograph, 1879, embody the method and apparatus described and referred to in the fifth claim of Bell's patent, No. 174,465?

*Ans.* It does.

*Cross-Int.* 45. Do you understand that the invention referred to in said fifth claim is an apparatus *necessarily* capable of transmitting and reproducing articulate words?

*Ans.* I do.

*Cross-Int.* 46. What do you understand to be referred to by the words "other sounds" in said claim?

*Ans.* Any sounds other than vocal sounds.

*Cross-Int.* 47. Do you understand that an apparatus which is capable of transmitting sounds other than vocal sounds, not articulate words, by causing electrical undulations similar in form to such sounds, would embody the invention described in said fifth claim?

*Ans.* I do.

*Cross-Int.* 48. Do you find in the apparatus of the defendants, when placed in electrical circuit with each other by means of a line wire, the invention or inventions referred to in any of the other claims of the first Bell patent except the fifth claim?

*Ans.* If we consider the telephone as in any sense a form of telegraph, it might be considered as embodying the system described in claim 1, in which the receiver is set in vibration by the employment of undulatory currents of electricity. It also utilizes a method of producing electrical undulations described in claim 4.

*Cross-Int.* 49. Do you understand that any particular apparatus is referred to in claims 1 and 4?

*Ans.* As I read these claims they are intended to cover the art

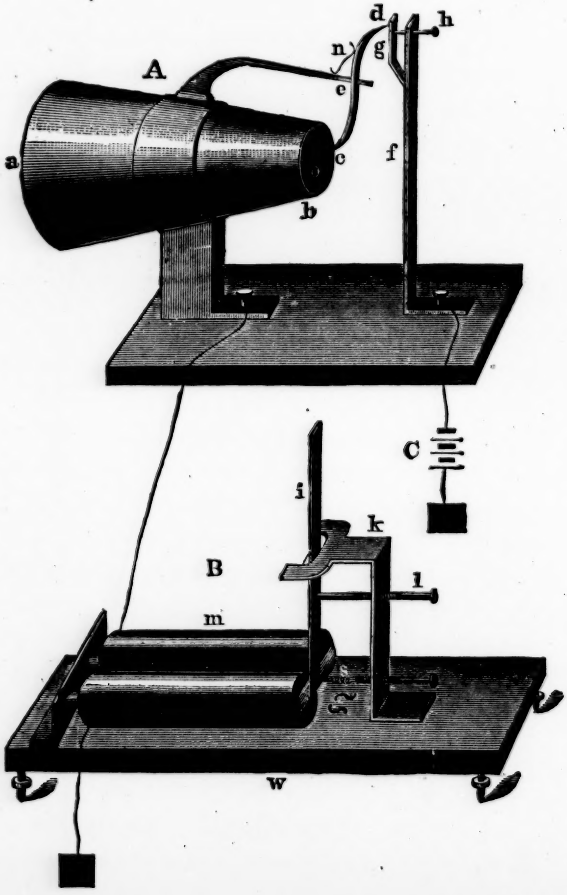
invented by Mr. Bell as a whole rather than any single particular form of apparatus.

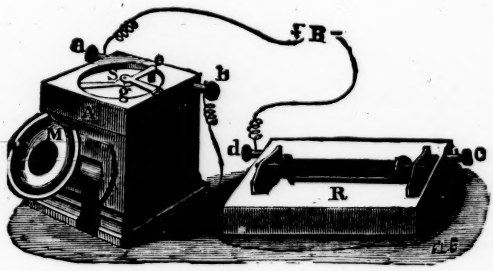
*Cross-Int.* 50. You have referred in your direct examination to the Reis transmitting instrument. Have you performed any experiments with the Reis transmitters and Reiss receivers?

*Ans.* I have.

*Cross-Int.* 51. What forms of Reis instruments have you experimented with? If any of them are described or illustrated in Prescott's work on the speaking telephone, please point them out.

*Ans.* I have used the Reis receiver figured on page 13 of the book mentioned, edition of 1879, and also the apparatus shown on page 10.






*Cross-Int.* 52. Have you ever used or experimented with any other forms of Reis instruments than those specified?

*Ans.* I have tried various other circuit-breaking instruments at different times and for different purposes, which involved the principles and mode of operation of the Reis instrument.

*Cross-Int.* 53. When you experimented with the Reis instruments shown on pages 10 and 13 of said Prescott's book, what was the material which you used for the electrodes?

*Ans.* Platinum, mercury, brass and other substances.

*Cross-Int.* 54. What other substances?

*Ans.* Copper, iron and steel.

*Cross-Int.* 55. What form of Reis instrument did you ever use with iron electrodes?

*Ans.* An instrument operating in the same manner as the Reis, but quite different in its outward appearance, which I once had constructed.

*Cross-Int.* 56. Did you ever experiment with an instrument with the same form and mode of construction as either of the Reis transmitters shown on pages 10 and 13 of said Prescott's book, but made with iron electrodes instead of platinum?

*Ans.* I cannot answer this question as to the exact form, without a reference to my note-books and apparatus.

*Cross-Int.* 57. Suppose a Reis transmitter of the form shown on page 10 or page 13 of said Prescott's work is spoken into so softly as not to cause any actual separation of the electrodes, will not such transmitter act so as to vary the electric current so as to produce in such current an undulation corresponding in form to the sound spoken into such transmitter?

*Ans.* When operated in the manner described, the transmitter figured on page 10 will do this.

*Cross-Int.* 58. In your opinion will the efficiency of the Reis transmitter vary with the kind of material which is used for the electrodes?

*Ans.* For use as a Reis transmitter the efficiency is doubtless much influenced by the nature of the electrodes, which is well known to be the case in all circuit breakers.

*Cross-Int.* 59. Suppose a Reis transmitter of the form shown on page 10 of said Prescott's work is spoken into so softly as not to cause any actual separation of the electrodes; will not such transmitter produce in the electric current in the line wire a series of undulations corresponding to the "quality" of the sounds spoken into such transmitter? I use the term "quality" in the sense in which you have used it in speaking of the characteristics of sound vibrations.

*Ans.* It will.

*Cross-Int.* 60. Do you find in either of the defendants' instruments, Exhibit Eaton Magneto Telephone or Exhibit Eaton Battery Transmitter, the subject matter of the third or seventh claims of the second Bell patent, No. 186,787?

*Ans.* I do. I find the plate of iron which can be thrown into vibration by the movement of the surrounding air or by the attraction of the magnet in combination with an electro-magnet. I also find the form of mouthpiece which is ordinarily used with the Bell magneto telephone, and which embodies important features of the mouthpiece or speaking tube in the narrow air space and the central aperture as described in claim 7. These last peculiarities are found in both the Eaton battery transmitter and Eaton magneto telephone. The peculiarities mentioned in claim 3 are possessed by the Eaton magneto telephone.

*Cross-Int.* 61. I understand you to mean that in your opinion the Eaton magnet telephone embodies the inventions described and referred to in claims 3 and 7; and that the Eaton battery transmitter embodies the invention described and referered to in claim 7 of the Bell patent, No. 186,787. Am I right?

*Ans.* Understanding claim 7, as I do, to include the parts repre-

sented in the diagram in front of the vibrating plate, as I have already described, you are right in your understanding of my answer.

*Cross-Int.* 62. Do you know why no evidence was called for or given on your direct examination, in reference to the alleged infringement of claims 1 and 4 of the first Bell patent, and of claims 3 and 7 of the second Bell patent since you say that in your opinion the defendants' apparatus embody the subject matter of all said claims?

*Ans.* I do not.

*Cross-Int.* 63. Do you believe that the subject matter of the third claim of the second Bell patent is new with Mr. Bell?

*Ans.* Not as a whole.

*Cross-Int.* 64. What do you mean by "not as a whole"?

*Ans.* Previous to Mr. Bell's time a similar arrangement to that mentioned in claim 3 had been proposed by different persons as a substitute for the Reis receiver. It was not known, however, before Mr. Bell's invention, that a plate of iron or other metal could take up from the air the vibrations produced by the human voice to such a degree as to vibrate in correspondence with them, and thus become capable of being used in a telephonic transmitter.

*Cross-Int.* 65. Do you mean to say that the combination described in said third claim had been previously made or described by others, but that its use as a transmitting instrument had not been so described?

*Ans.* I do.

*Cross-Int.* 66. By whom had such combination been previously described?

*Ans.* I showed an apparatus of this kind in my public lectures in 1872 and in 1873. An apparatus of the same general character had previously been used in an experiment by Professor Pickering, and in experiments by Dr. Van der Weyde. In all these cases the apparatus was intended to be used as a receiver.

*Cross-Int.* 67. Was such combination also described, to your knowledge, in public works?

*Ans.* The receiver shown on page 10 of Prescott's work, already referred to, is of the same general class.

*Cross-Int.* 68. Does the receiver shown on page 10 of said

Prescott's work embody, in your opinion, the combination described in said third claim?

*Ans.* Not as a whole, unless the iron plate there shown is capable of being thrown into vibration by the movement of surrounding air, as well as by the attraction of the magnet.

*Cross-Int.* 69. What is your opinion on that point as to the capability of said plate?

*Ans.* What I have said in a previous answer regarding the apparatus shown in Fig. 5 of Mr. Bell's first patent will apply equally here. I cannot give any more definite opinion in the absence of experiment.

*Cross-Int.* 70. Do you find the subject matter of the seventh claim of the Bell patent, No. 186,787, shown or described in Fig. 7 of the first Bell patent?

*Ans.* In Fig. 7 the cones are hearing and speaking tubes. I understand claim 7 to refer to particular modifications of these, such as are described and shown in the figures accompanying the second patent.

*Cross Int.* 71. What particular modifications do you understand the claim 7 of the second patent is limited to?

*Ans.* I have always supposed that Mr. Bell intended to claim the tube marked E in the drawing, whether this were made longer or shorter; the position of this tube so placed as to deliver the impulse of the voice at the centre of the diaphragm; and the manner of mounting of the speaking tube, which leaves an air space in front of the diphragm.

*Cross-Int.* 72. Referring to Prescott's description of the Reis telephone, on page 9 of his work, already referred to; what do you understand by the following words: "For the sake of clearness, the appliances by which the apparatus is arranged for reciprocal transmission in one direction or the other have been omitted"?

*Ans.* I do not know what idea the author of the work in question intended that its readers should draw from the words quoted.

*Cross-Int.* 73. What do you understand those words to mean?

*Ans.* I should suppose that there was a duplicate transmitter and a duplicate receiver arranged in some way so that sounds could be

transmitted from either of two stations to the other by the use of suitable switches or other connections.

[*Adjourned.*]

BOSTON, Jan. 29, 1881.

*Cross-Int.* 74. Do you understand from the words quoted in the seventy-second cross-question, from Prescott's work, that there is at each station at the end of the line connecting the two, a transmitter and also a receiver of the kind shown and described, so that sounds could be transmitted and received from either station at the other, over the same line?

*Ans.* I suppose that in the paragraph from which the quotation is made the author of the work intends to indicate the way in which such apparatus should be set up and arranged, if for any reason a reciprocal transmission of sound between two stations was desired. I am not aware that Reis, in his experiments, attempted this reciprocity; and as there is no way in which, when the instruments in question are operated in the manner described by Reis, [the only manner known previous to the invention by Mr. Bell,] this reciprocal transmission could be secured except by such duplication of instruments; that is the way in which I understand the statement in the quotation referred to.

*Cross-Int.* 75. If the apparatus described in Prescott's work should be arranged for reciprocal transmission, as stated by Mr. Prescott, so that there was a receiver like that called B at each station, would such an arrangement of the apparatus show the combination of devices illustrated in Fig. 5 of the first Bell patent?

*Ans.* Such an apparatus might, to a superficial observer, seem to show the combination of devices illustrated in Fig. 5 of the first Bell patent, but would, nevertheless, if operated in any manner described or known previous to Mr. Bell's invention, be an entirely different apparatus from Mr. Bell's, and would operate in an entirely different manner from that described by him in the patent referred to.

*Cross-Int.* 76. I do not ask about the operation of the apparatus or the method in which they are described as set in motion in Prescott's book; but whether, if the apparatus should be arranged for

reciprocal transmission, as stated by Prescott, the two receiving instruments, one at each end of the line, could not be so connected that they would correspond in their mechanical construction and connection, with the combination of devices illustrated in Fig. 5 of the first Bell patent.

*Ans.* They could be so connected.

*Cross-Int.* 77. According to the description given by Prescott, do you understand them to be so connected?

*Ans.* I do not know.

*Cross-Int.* 78. In your answer to the nineteenth interrogatory you referred to several publications by Du Moncel, as showing that it was understood by electricians that the resistance of a circuit could be varied by variations in the amount of pressure between two electrodes n contact. Do you know any other author who ever called attention to such fact prior to the date of Mr. Bell's first patent?

*Ans.* M. Clérac, as I have previously stated, had utilized this property in certain electrical apparatus.

*Cross-Int.* 79. Do you not know that, only from a publication of Du Moncel's, which is subsequent in date to said Bell patent?

*Ans.* I had forgotten that Du Moncel referred to Clérac's tube until yesterday, when I noticed a reference to it in a paragraph in one of his books. I have been aware, however, of Clérac's invention since the controversy began between Mr. Edison and Mr. Hughes, in regard to the invention of the microphone in which controversy Clérac's tube was frequently mentioned. I have not taken the trouble to hunt up the original statement of Clérac, as I have never had any occasion to do this; and of the fact itself there is no doubt.

*Cross-Int.* 80. The seventy-eighth cross-question called for your knowledge of any author who had mentioned the fact in question prior to the date of Mr. Bell's first patent. Do you know of any author, or any publication upon the subject, other than those of Du Moncel?

*Ans.* M. Clérac himself, I understand, published a description of his invention. Also, as I have said, the necessity of firm pressure in the contact pieces has long been recognized. Beyond the facts stated, I have no knowledge sufficiently definite to cite particular authors or particular books. I have made no search, however, to

find such references, and have only given those to which my attention had been particularly called, or of what I happened to retain a precise recollection. If it is desired that I should do so, I do not doubt that I could obtain other allusions to the subject in question.

*Cross-Int.* 81. Do you understand that Du Moncel, or Clérac, or any other persons had, previous to Mr. Bell's patent, discovered any substance for an electrode by the use of which, variations in resistance under varying pressure corresponded in magnitude with such variations in pressure?

*Ans.* It was certainly known that several substances showed diminished resistance under increased pressure, and increased resistance under diminished pressure. I do not know to what precise extent quantitative measurements were made. In fact, for the proof of this correspondence of variation, when the minutest changes in pressure, such as occur under the influence of the voice with the speaking telephone, are considered, there was almost needed the speaking telephone itself as an instrument of investigation. I think, however, that sufficient was known before the date of Mr. Bell's patent, to enable an inventive mind, possessing this knowledge and turning its attention to the problem, to apply this principle to the construction of a battery transmitter for the transmission of articulate speech.

*Cross-Int.* 82. Do you not think that after the date of Mr. Bell's first patent, and in view of the state of the art which existed before such patent, it required invention of a high order to discover a substance in which variations in resistance under varying pressure, corresponded in magnitude with such variations in pressure, and to apply the same to the use of electrodes in contact in a speaking telephone?

*Ans.* It is very hard to decide, in the light of our present knowledge, what degree of inventiveness was required to do this. Most certainly, however, the battery transmitter using solid electrodes is a very important practical step.

*Cross-Int.* 83. What is the material of the electrodes in contact with each' other in defendants' instrument, Eaton battery transmitter?

*Ans.* The electrodes in defendants' instrument seem to be one

metallic, and the other seemingly made of some finely divided substance, apparently metallic and held together by some pasty material. I have made no analysis of the button used in the battery transmitter, but it is apparently a form of compressible button, such as described in the Eaton patent, No. 217,930.

*Cross-Int.* 84. In your answer to the thirty-seventh cross-question, you mentioned carbon as a substance which had the capacity of varying in resistance in an electric current in correspondence with pressure. What do you mean by carbon? Do you include all forms of carbon?

*Ans.* I should not include the diamond in the statement, because I do not know very much about its conducting power. I think plumbago would probably operate in this manner. The different varieties of lampblack, gas carbon, and similar forms, possess this property.

*Direct Examination resumed.*

*Int.* 85. In Cross-Ints. 57 and 59 you were asked as to the use of the Reis transmitter, and what it would do under the supposition that it should be spoken into so softly as not to cause any actual separation of the electrodes. Do you know of any description of its use in the manner supposed, or any use of it in that manner, before the date of Mr. Bell's first patent?

*Ans.* I do not.

*Int.* 86. Had your attention been specially directed to the first and fourth claims of the first Bell patent, before this examination was commenced?

*Ans.* It had not.

*Int* 87. Do you find in those claims the reference to the specification?

*Ans.* I do in the terms as set forth.

*Int.* 88. You have spoken of the apparatus referred to in the fifth claim of that patent as one which was put into operation by sound waves acting on the diaphragm of the transmitter, for the purpose of transmitting to and reproducing from the receiver vocal or other sounds acting on the transmitter. Will you refer to the specification and state whether you find the apparatus shown in Fig. 5, described as an apparatus put into operation in a different

way so as to produce simultaneously at the transmitting and receiving instruments sounds which the apparatus is capable of producing of longer or shorter duration to correspond with the signals used in the Morse method of telegraphing?

*Ans.* I find that it is so described, the statement being made that the armature can be set in vibration in a variety of ways.

*Int.* 89. If one way is stated as an illustration of the ways in which the apparatus shown in Fig. 5 may be used, will you state what it is, and whether or not it is, in your judgment, substantially different from the method in which the apparatus shown in Fig. 7 is used?

[*Objected to, for the reason that the fact that one way of operating the device shown in Fig. 5 is different from one way of operating the device shown in Fig. 7 is immaterial.*]

*Ans.* The specification states the armature *c* can be set in vibration in a variety of ways, one of which is by wind; and in vibrating, it produces a musical note of a certain definite pitch. When vibrated in this way, the manner of vibration and the action of the apparatus are substantially different from the manner of vibration and the operation of the apparatus shown in Fig. 7.

*Int.* 90. Do you understand that when the armatures in the apparatus shown in Fig. 5 are vibrated by wind, or in any similar manner, the sound or the sound waves produced by the vibration of the armature of the transmitter operate upon the instrument in any such way as they do in the apparatus shown in Fig. 7, or in any way at all for the purpose of operating the instrument?

[*Objected to as leading.*]

*Ans.* They do not.

*Int.* 91. Do you find anything in the specification relating to the apparatus shown in Fig. 7, which indicates that it was to be used or put in operation in the manner in which the apparatus shown in Fig. 5 is described as being used or put in operation?

[*Same objection and also as immaterial.*]

*Ans.* I do not.

*Int.* 92. Do you find represented in the drawings of the patent a combination of the instruments like those shown in Fig. 5; and is there anything in the specification showing that when so combined

tones of different pitch could be produced in different transmitters and receivers simultaneously, so that each might be employed or used for transmitting messages by the Morse signals?

[*Same objections.*]

*Ans.* I find in Fig. 6 a representation of the combination of such instrument. I find in the specification the paragraph beginning "a number of instruments may be placed in a telegraphic circuit as in Fig. 6," which shows the manner in which they may be thus employed.

*Int.* 93. Do you find anything in the construction of the defendants' instruments which have been produced in evidence, to indicate that they were designed to be used or were adapted to be used by applying force to them in any other way than by sound waves, as, for instance, by wind?

[*Objected to as speculation.*]

*Ans.* I do not.

*Int.* 94. If the first and fourth claims of the patent were to be so construed as to be limited to instruments like those shown in Fig. 5, and operated in the manner in which it is said they are to be operated, to the exclusion of instruments like those shown in Fig. 7, and operated in the manner in which they are to be operated, that is, by sound waves; would you then understand that the defendants' instruments embodied the inventions referred to and embraced in those claims?

[*Objected to as founded on an inadmissible assumption, and as involving a question of law.*]

*Ans.* I should not.

*Int.* 95. In your answer to the twenty-seventh cross-interrogatory you say that the instrument shown at Fig. 5 represents an apparatus adapted to the transmission of certain sounds telegraphically. Will you state what you mean by certain sounds, and whether the apparatus is described as being designed to transmit them by the action of the sounds themselves upon the instrument, or by putting the instrument in operation by wind or in some similar manner?

[*Objected to as leading; also because the witness has stated that he has not sufficiently experimented with the apparatus shown in Fig.*

*5 to understand its capacity; also because what the apparatus is described as being designed to do, is not so material as what it will or will not in fact do.*]

*Ans.* In my answers to Cross-Ints. 27, 28, 29 and 30, I considered the apparatus only as figured, and without any reference to the particular manner in which the specification described it as being operated. And my answers should be understood in accordance with this intention. The only sounds which such an apparatus could transmit, would be those corresponding to the limited ways in which the armature could vibrate. The apparatus as described in the specification is, however, intended to be put in operation, as there stated, by wind and some other similar manner.

*Int.* 96. In your answer to Cross-Int. 71 you state what you understand Mr. Bell intended to claim in the seventh claim of the second patent. If that claim were to be construed as limited to a combination in which a tube of greater or less length should be used, so as to place the flaring orifice at some distance from the cover in front of the plate instead of in it, should you then think that the defendants' instruments embraced the combination?

*Ans.* I should not.

*Int.* 97. In your answer to Cross-Int. 70, you say in Fig. 7, referring to the first patent, the cones are hearing and speaking tubes, and that you understand claim 7 to refer to particular modifications of these such as are described and shown in the figures accompanying Bell's second patent. Do you understand, from your experiments with the telephone, or from the consideration you have given the instruments, that the modification of the tube shown in the second patent constitutes a substantial improvement over those shown in Fig. 7 of the first patent?

[*Objected to as leading.*]

*Ans.* I think it a very important practical improvement.

*Int.* 98. If you have ascertained by experiment or observation what results or effects are obtained by the use of a plate or cover immediately in front of the vibrating diaphragm, as shown in the second Bell patent, with a small orifice over the middle of the diaphragm and the mouthpiece, substantially like that shown in the

drawings, either with or without the elongated tube, will you state what those results are?

*Ans.* Sounds are louder and much more distinct than they are without the use of such device.

*Int.* 99. In your answer to Cross-Int. 64, you say it was not known before Mr. Bell's invention that a plate of iron or other metal would take up the air vibrations produced by the human voice to such a degree as to vibrate in correspondence with them and become capable of being used in a telephone transmitter. Was it, so far as you know, known before the date of Mr. Bell's invention, that such plates could be put into vibration by an electro-magnet and a current, in such a way as to give out the tones of the human voice or articulate speech?

[*Objected to immaterial.*]

*Ans.* It was not. In fact we had no means of measurement sufficiently delicate and suitable to determine this question.

*Int.* 100. If the third claim of the second Bell patent were to be construed as embracing the combination of an electro-magnet, such as is described in the specification and referred to in the fifth claim, with a plate combined with a cover or sounding box, as shown in that patent, as essential elements, would the defendants' apparatus, under such construction, embrace such combination?

[*Objected to as founded on an inadmissible assumption, and as involving a question of law.*]

*Ans.* The complainants' Exhibit Eaton's Magneto Telephone shows a plate of the kind mentioned, in combination with an electro-magnet having a coil upon its end nearest the plate and placed in a sounding box, substantially as set forth in the second Bell patent.

CHAS. R. CROSS.

Attest: CHAS H. SWAN, *Examiner.*

2 Sheets—Sheet 1.

# A. G. BELL.

## TELEGRAPHY.

No. 174,465. Patented March 7, 1876

*Fig. 1.*

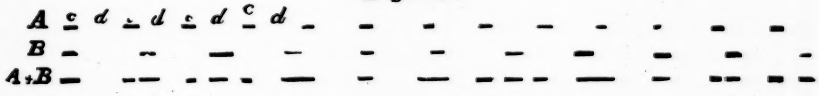



*Fig. 2.*

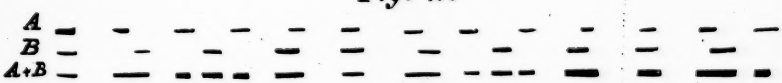



*Fig. 3*

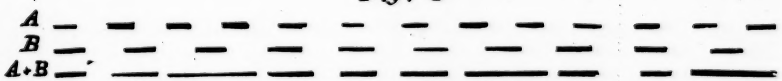



*Fig. 4.*

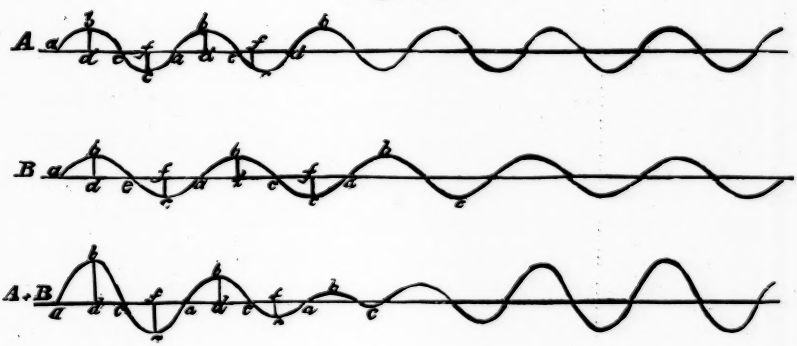



*Fig. 5.*

*Witnesses:*

Ewell Storck

W. J. Hinkelmann

*Inventor:*

A. Graham Bell

by Atty Pollock & Bailey

2 Sheets—Sheet 2

A. G. BELL.

TELEGRAPHY

No. 174,465. Patented March 7, 1876.

3969

*Fig. 6.*

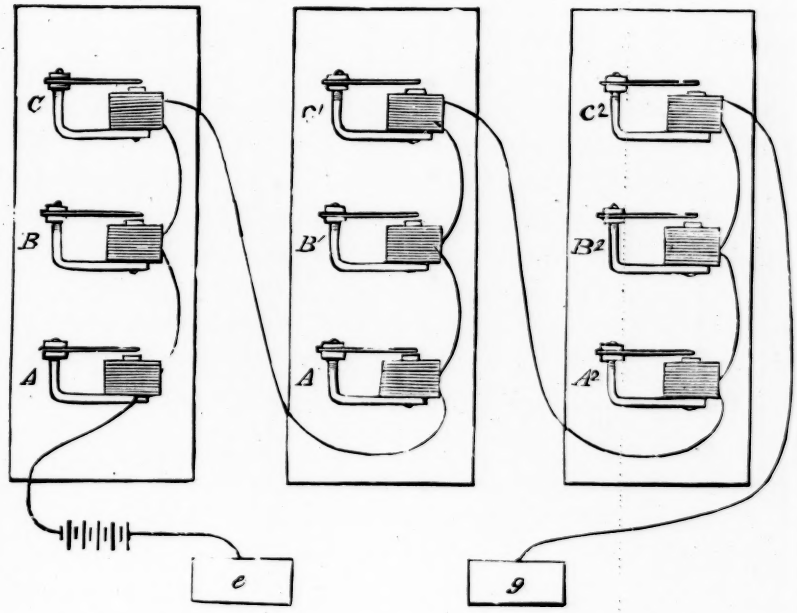
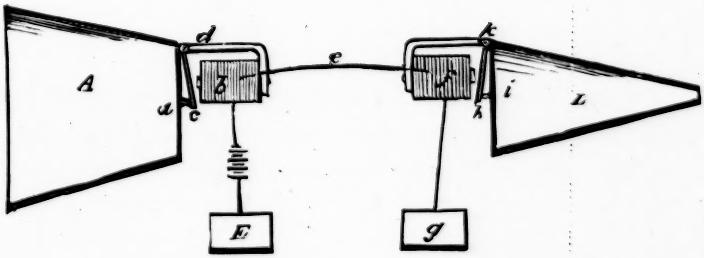



*Fig. 7*




*Witnesses:*

Ewell Stock,

H. J. Hunteman

*Inventor:*

A. Graham Bell

by attys Pollock & Bailey

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UNITED STATES PATENT OFFICE.

ALEXANDER GRAHAM BELL, OF SALEM, MASSACHUSETTS.

# IMPROVEMENT IN TELEGRAPHY.

Specification forming part of Letters Patent No. 174,465; dated March 7, 1876, application filed February 14, 1876.

*To all whom it may concern:*

Be it known that I, Alexander Graham Bell, of Salem, Massachusetts, have invented certain new and useful Improvements in Telegraphy, of which the following is a specification:

In Letters Patent granted to me April 6, 1875, No. 161,739, I have described a method of, and apparatus for transmitting two or more telegraphic signals simultaneously along a single wire by the employment of transmitting-instruments, each of which occasions a succession of electrical impulses differing in rate from the others; and of receiving-instruments, each tuned to a pitch at which it will be put in vibration to produce its fundamental note by one only of the transmitting-instruments; and of vibratory circuit-breakers operating to convert the vibratory movement of the receiving-instrument into a permanent make or break (as the case may be) of a local circuit, in which is placed a Morse sounder, register, or other telegraphic apparatus. I have also therein described a form of autograph-telegraph based upon the action of the above-mentioned instruments.

In illustration of my method of multiple telegraphy, I have shown in the patent aforesaid, as one form of transmitting-instrument, an electro-magnet having a steel-spring armature, which is kept in vibration by the action of a local battery. This armature in vibrating makes and breaks the main circuit, producing an intermittent current upon the line-wire. I have found, however, that upon this plan, the limit to the number of signals that can be sent simultaneously over the same wire is very speedily reached; for, when a number of transmitting-instruments having different rates of vibration are simultaneously making and breaking the same circuit, the

effect upon the main line is practically equivalent to one continuous current.

In a pending application for Letters Patent, filed in the United States Patent Office, Feb. 25, 1875, I have described two ways of producing the intermittent current — the one by actual make and break of contact, the other by alternately increasing and diminishing the intensity of the current without actually breaking the circuit. The current produced by the latter method I shall term, for distinction sake, a "pulsatory current."

My present invention consists in the employment of a vibratory or undulatory current of electricity in contradistinction to a merely intermittent or pulsatory current, and of a method of and apparatus for producing electrical undulations upon the line-wire.

The distinction between an undulatory and a pulsatory current will be understood by considering that electrical pulsations are caused by sudden or instantaneous changes of intensity, and that electrical undulations result from gradual changes of intensity, exactly analogous to the changes in the density of air occasioned by simple pendulous vibrations. The electrical movement, like the aerial motion, can be represented by a sinusoidal curve or by the resultant of several sinusoidal curves.

Intermittent or pulsatory and undulatory currents may be of two kinds, accordingly as the successive impulses have all the same polarity or are alternately positive and negative.

The advantages I claim to derive from the use of an undulatory current in place of a merely intermittent one are, first, that a very much larger number of signals can be transmitted simultaneously on the same circuit; second, that a closed circuit and single main battery may be used; third, that communication in both directions is established without the necessity of special induction-coils; fourth, that cable-despatches may be transmitted more rapidly than by means of an intermittent current or by the methods at present in use, for, as it is unnecessary to discharge the cable before a new signal can be made, the lagging of cable-signals is prevented; fifth, and that as the circuit is never broken a spark-arrester becomes unnecessary.

It has long been known that when a permanent magnet is caused to approach the pole of an electro-magnet a current of electricity is

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induced in the coils of the latter, and that when it is made to recede, a current of opposite polarity to the first appears upon the wire. When, therefore, a permanent magnet is caused to vibrate in front of the pole of an electro-magnet, an undulatory current of electricity is induced in the coils of the electro-magnet, the undulations of which correspond, in rapidity of succession, to the vibrations of the magnet, in polarity to the direction of its motion, and in intensity to the amplitude of its vibration.

That the difference between an undulatory and an intermittent current may be more clearly understood, I shall describe the condition of the electrical current when the attempt is made to transmit two musical notes simultaneously — first upon the one plan, and then upon the other. Let the interval between the two sounds be a major third; then their rates of vibration are in the ratio of 4 to 5. Now, when the intermittent current is used, the circuit is made and broken four times by one transmitting-instrument in the same time that five makes and breaks are caused by the other. A and B, Figs. 1, 2, and 3, represent the intermittent currents produced, four impulses of B being made in the same time as five impulses of A. *c c c*, &c., show where and for how long time the circuit is made, and *d d d*, &c., indicate the duration of the breaks of the circuit. The line A and B shows the total effect upon the current when the transmitting-instruments for A and B are caused simultaneously to make and break the same circuit. The resultant effect depends very much upon the duration of the make relatively to the break. In Fig. 1 the ratio is as 1 to 4; in Fig. 2, as 1 to 2, and in Fig 3 the makes and breaks are of equal duration. The combined effect, A and B, Fig. 3, is very nearly equivalent to a continuous current.

When many transmitting-instruments of different rates of vibration are simultaneously making and breaking the same circuit the current upon the main line becomes for all practical purposes continuous.

Next, consider the effect when an undulatory current is employed. Electrical undulations, induced by the vibration of a body capable of inductive action, can be represented graphically, without error, by the same sinusoidal curve which expresses the vibration of the nducing body itself, and the effect of its vibration upon the air; or, as above stated, the rate of oscillation in the electrical current

corresponds to the rate of vibration of the inducing body — that is, to the pitch of the sound produced. The intensity of the current varies with the amplitude of the vibration — that is, with the loudness of the sound; and the polarity of the current corresponds to the direction of the vibrating body — that is, to the condensations and rarefactions of air produced by the vibration. Hence, the sinuosoidal curve A or B, Fig. 4, represents graphically the electrical undulations induced in a circuit by the vibration of a body capable of inductive action.

The horizontal line *a d e f*, &c., represents the zero of current. The elevations *b b b*, &c., indicate impulses of positive electricity. The depressions *c c c*, &c., show impulses of negative electricity. The vertical distance *b d* or *c f* of any portion of the curve from the zero-line expresses the intensity of the positive or negative impulse at the part observed, and the horizontal distance *a a* indicates the duration of the electrical oscillation. The vibrations represented by the sinusoidal curves B and A, Fig. 4, are in the ratio aforesaid, of 4 to 5 — that is, four oscillations of B are made in the same time as five oscillations of A.

The combined effect of A and B, when induced simultaneously on the same circuit, is expressed by the curve A×B, Fig. 4, which is the algebraical sum of the sinusoidal curves A and B. This curve A×B also indicates the actual motion of the air when the two musical notes considered are sounded simultaneously. Thus, when electrical undulations of different rates are simultaneously induced in the same circuit, an effect is produced exactly analogous to that occasioned in the air by the vibration of the inducing bodies. Hence the coexistence upon a telegraphic circuit of electrical vibrations of different pitch is manifested, not by the obliteration of the vibratory character of the current, but by peculiarities in the shapes of the electrical undulations, or, in other words, by peculiarities in the shapes of the curves which represent those undulations.

There are many ways of producing undulatory currents of electricity, dependent for effect upon the vibrations or motions of bodies capable of inductive action. A few of the methods that may be employed I shall here specify. When a wire, through which a continuous current of electricity is passing, is caused to vibrate in the

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neighborhood of another wire, an undulatory current of electricity is induced in the latter. When a cylinder, upon which are arranged bar-magnets, is made to rotate in front of the pole of an electro-magnet, an undulatory current of electricity is induced in the coils of the electro-magnet.

Undulations are caused in a continuous voltaic current by the vibration or motion of bodies capable of inductive action, or by the vibration of the conducting-wire itself in the neighborhood of such bodies. Electrical undulations may also be caused by alternately increasing and diminishing the resistance of the circuit, or by alternately increasing and diminishing the power of the battery. The internal resistance of a battery is diminished by bringing the voltaic elements nearer together, and increased by placing them farther apart. The reciprocal vibration of the elements of a battery, therefore, occasions an undulatory action in the voltaic current. The external resistance may also be varied. For instance, let mercury or some other liquid form part of a voltaic circuit, then the more deeply the conducting-wire is immersed in the mercury or other liquid the less resistance does the liquid offer to the passage of the current. Hence, the vibration of the conducting-wire in mercury or other liquid included in the circuit occasions undulations in the current. The vertical vibrations of the elements of a battery in the liquid in which they are immersed, produces an undulatory action in the current by alternately increasing and diminishing the power of the battery.

In illustration of the method of creating electrical undulations, I shall show and describe one form of apparatus for producing the effect. I prefer to employ for this purpose an electro-magnet. A, Fig. 5, having a coil upon only one of its legs *b*. A steel-spring armature, *c*, is firmly clamped by one extremity to the uncovered leg *d* of the magnet, and its free end is allowed to project above the pole of the covered leg. The armature *c* can be set in vibration in a variety of ways, one of which is by wind, and, in vibrating, it produces a musical note of a certain definite pitch.

When the instrument A is placed in a voltaic circuit, *g b e f g*, the armature *c* becomes magnetic, and the polarity of its free end is opposed to that of the magnet underneath. So long as the armature *c* remains at rest, no effect is produced upon the voltaic current;

but the moment it is set in vibration to produce its musical note, a powerful inductive action takes place, and electrical undulations traverse the circuit *g b e f g*. The vibratory current passing through the coil of the electro-magnet *f*, causes vibration in its armature *h*, when the armatures *c h* of the two instruments A I are normally in unison with one another; but the armature *h* is unaffected by the passage of the undulatory current when the pitches of the two instruments are different.

A number of instruments may be placed upon a telegraphic circuit, as in Fig. 6. When the armature of any one of the instruments is set in vibration all the other instruments upon the circuit which are in unison with it respond, but those which have normally a different rate of vibration, remain silent. Thus if A, Fig. 6, is set in vibration, the armatures of $A^1$ and $A^2$ will vibrate also, but all the others on the circuit will remain still. So if $B^1$ is caused to emit its musical note the instruments B $B^2$ respond. They continue sounding so long as the mechanical vibration of $B^1$ is continued, but become silent with the cessation of its motion. The duration of the sound may be used to indicate the dot or dash of the Morse alphabet, and thus a telegraphic dispatch may be indicated by alternately interrupting and renewing the sound. When two or more instruments of different pitch are simultaneously caused to vibrate, all the instruments of corresponding pitches upon the circuit are set in vibration, each responding to that one only of the transmitting-instruments with which it is in unison. Thus the signals of A, Fig. 6, are repeated by $A^1$ and $A^2$, but by no other instrument upon the circuit; the signals of $B^2$ by B and $B^1$, and the signals of $C^1$ by C and $C^2$ — whether A, $B^2$, and $C^1$ are successively or simultaneously caused to vibrate. Hence, by these instruments, two or more telegraphic signals or messages may be sent simultaneously over the same circuit without interfering with one another.

I desire here to remark that there are many other uses to which these instruments may be put, such as the simultaneous transmission of musical notes, differing in loudness as well as in pitch, and the telegraphic transmission of noises or sounds of any kind.

When the armature *c*, Fig. 5, is set in vibration, the armature *h* responds not only in pitch but in loudness. Thus, when *c* vibrates with little amplitude, a very soft musical note proceeds

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from *h*; and when *c* vibrates forcibly, the amplitude of the vibration of *h* is considerably increased, and the resulting sound becomes louder. So, if A and B, Fig. 6, are sounded simultaneously (A loudly and B softly,) the instruments, $A^1$ and $A^2$, repeat loudly the signals of A, and $B^1$ $B^2$ repeat softly those of B.

One of the ways in which the armature *c*, Fig. 5, may be set in vibration has been stated above to be by wind. Another mode is shown in Fig. 7, whereby motion can be imparted to the armature by the human voice or by means of a musical instrument.

The armature *c*, Fig. 7, is fastened loosely by one extremity to the uncovered leg *d* of the electro-magnet *b*, and its other extremity is attached to the centre of a stretched membrane, *a*. A cone, A, is used to converge sound-vibrations upon the membrane. When a sound is uttered in the cone the membrane *a* is set in vibration, the armature *c* is forced to partake of the motion, and thus electrical undulations are created upon the circuit E *b e f g*. These undulations are similar in form to the air vibrations caused by the sound — that is, they are represented graphically by similar curves. The undulatory current passing through the electro-magnet *f* influences its armature *h* to copy the motion of the armature *c*. A similar sound to that uttered into A is then heard to proceed from L.

In this specification the three words "oscillation," "vibration," and "undulation" are used synonymously, and in contradistinction to the terms "intermittent" and "pulsatory." By the term "body capable of inductive action," I mean a body which, when in motion, produces dynamical electricity. I include in the category of bodies capable of inductive action brass, copper, and other metals, as well as iron and steel.

Having described my invention, what I claim and desire to secure by Letters Patent, is as follows:

1. A system of telegraphy in which the receiver is set in vibration by the employment of undulatory currents of electricity, substantially as set forth.

2. The combination, substantially as set forth, of a permanent magnet, or other body capable of inductive action, with a closed circuit, so that the vibration of the one shall occasion electrical undulations in the other, or in itself, and this I claim whether the permanent magnet be set in vibration in the neighborhood of the

conducting-wire forming the circuit, or whether the conducting-wire be set in vibration in the neighborhood of the permanent magnet, or whether the conducting-wire and the permanent magnet both simultaneously be set in vibration in each other's neighborhood.

3. The method of producing undulations in a continuous voltaic current by the vibration or motion of bodies capable of inductive action, or by the vibration or motion of the conducting-wire itself in the neighborhood of such bodies, as set forth.

4. The method of producing undulation, in a continuous voltaic circuit, by gradually increasing and diminishing the resistance of the circuit, or by gradually increasing and diminishing the power of the battery, as set forth.

5. The method of and apparatus for transmitting vocal or other sounds telegraphically, as herein described, by causing electrical undulations, similar in form to the vibrations of the air accompanying the said vocal or other sounds, substantially as set forth.

In testimony whereof I have hereunto signed my name this twentieth day of January, A. D. 1876.

ALEX. GRAHAM BELL.

Witnesses:

THOMAS E. BARRY.

P. D. RICHARDS.

2 Sheets—Sheet 1.

A. G. BELL.

ELECTRIC TELEGRAPHY.

No. 186,787. Patented Jan. 30, 1877.

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*Fig. 1.*

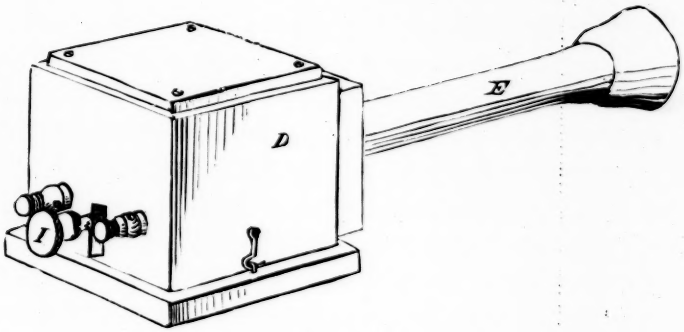



*Fig. 2.*

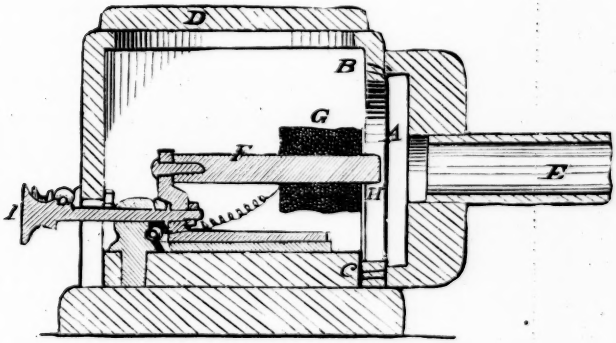
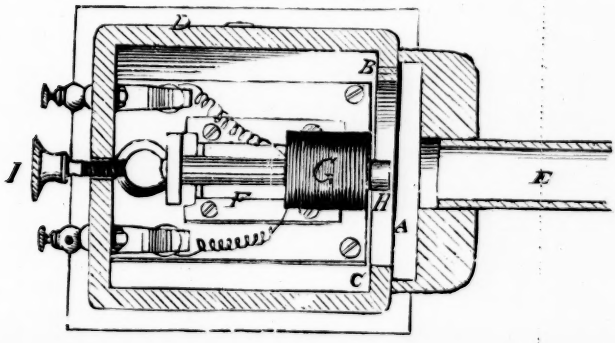



*Fig. 3.*




*Attest:*

A. Pollok

Ewell & Dick

*Inventor*

Alexander Graham Bell

A. G. BELL.

ELECTRIC TELEGRAPHY.

No. 186,787 Patented Jan. 30, 1877.

*Fig. 4.*

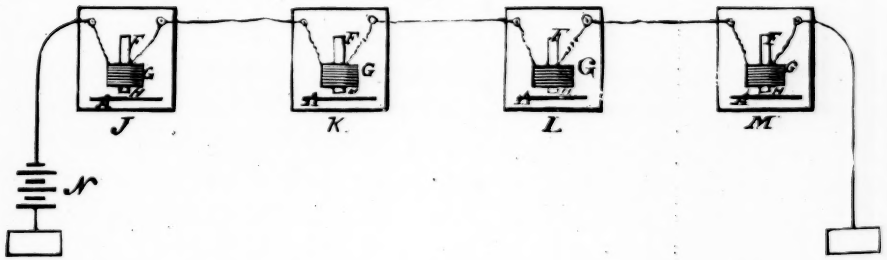



*Fig 5.*

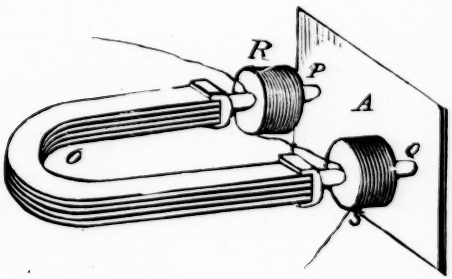
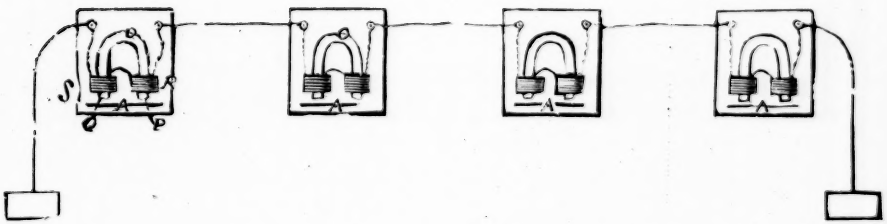



*Fig. 6.*




*Attest:*

A. Pollok
Ewell & Dick

*Inventor:*

Alexander Graham Bell

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UNITED STATES PATENT OFFICE.

ALEXANDER GRAHAM BELL, OF BOSTON, MASSACHUSETTS.

# IMPROVEMENT IN ELECTRIC TELEGRAPHY.

Specification forming part of Letters Patent No. 186,787, dated January 30, 1877; application filed January 15, 1877.

*To all whom it may concern:*

Be it known that I, Alexander Graham Bell, of Boston, Massachusetts, have invented certain new and useful Improvements in Electric Telephony, of which the following is a specification: —

In Letters Patent granted to me on the 6th day of April, 1875, No. 161,739, and in an application for Letters Patent of the United States now pending, I have described a method of and apparatus for producing musical tones by the action of a rapidly interrupted electrical current, whereby a number of telegraphic signals can be sent simultaneously along a single circuit.

In another application for Letters Patent now pending in the United States Patent Office, I have described a method of and apparatus for inducing an intermittent current of electricity upon a line-wire, whereby musical tones can be produced and a number of telegraphic signals be sent simultaneously over the same circuit, in either or in both directions; and in Letters Patent granted to me March 7, 1876, No. 174,465, I have shown and described a method of an apparatus for producing musical tones by the action of undulatory currents of electricity, whereby a number of telegraphic signals can be sent simultaneously over the same circuit, in either or in both directions, and a single battery be used for the whole circuit.

In the applications and patents above referred to, signals are transmitted simultaneously along a single wire by the employment of transmitting-instruments, each of which occasions a succession of electrical impulses differing in rate from the others, and are received without confusion by means of receiving-instruments, each tuned to

AMERICAN BELL TELEPHONE COMPANY, -16



a pitch at which it will be put in vibration to produce its fundamental note by one only of the transmitting-instruments. A separate instrument is therefore employed for every pitch, each instrument being capable of transmitting or receiving but a single note, and thus as many separate instruments are required as there are messages or musical notes to be transmitted.

My invention has for its object, first, the transmission simultaneously of two or more musical notes or telegraphic signals along a single wire, in either or both directions, and with a single battery for the whole circuit, without the use of as many instruments as there are musical notes or telegraphic signals to be transmitted; second, the electrical transmission by the same means of articulate speech, and sound of every kind, whether musical or not; third, the electrical transmission of musical tones, articulate speech, or sounds of every kind, without the necessity of using a voltaic battery.

In my patent No. 174,465, dated March 7, 1876, I have shown as one form of transmitting-instrument, a stretched membrane to which the armature of an electro-magnet is attached, whereby motion can be imparted to the armature by the human voice, or by means of a musical instrument, or by sounds produced in any way.

In accordance with my present invention I substitute for the membrane and armature shown in the transmitting and receiving instruments alluded to above a plate of iron or steel capable of being thrown into vibration by sounds made in its neighborhood.

The nature of my invention and the manner in which the same is or may be carried into effect will be understood by reference to the accompanying drawings, in which —

Figure 1 is a perspective view of one form of my electric telephone. Fig. 2 is a vertical section of the same, and Fig. 3 is a plan view of the apparatus. Fig. 4 is a diagram illustrating the arrangement upon circuit.

Similar letters in the drawings represent corresponding portions of the apparatus.

A in said drawings represents a plate of iron or steel, which is fastened at B and C to the cover or sounding-box D. E represents a speaking-tube, by which sounds may be conveyed to or from the

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plate A. F is a bar of soft iron. G is a coil of insulated copper wire, placed around the extremity of the end H of the bar F. I is an adjusting-screw, whereby the distance of the end H from the plate A may be regulated.

The electric telephones, J, K, L and M, are placed at different stations upon a line, and are arranged upon circuit with a battery, N, as shown in diagram, Fig. 4.

I have shown the apparatus in one of its simplest forms, it being well understood that the same may be varied in arrangement, combination, general construction and form, as well as material of which the several parts are composed.

The operation and use of this instrument are as follows: —

I would premise by saying that this instrument is and may be used both as a transmitter and as a receiver — that is to say, the sender of the message will use an instrument in every particular identical in construction and operation with that employed by the receiver, so that the same instrument can be used alternately as a receiver and a transmitter.

In order to transmit a telegraphic message by means of these instruments, it is only necessary for the operator at a telephone (say J) to make a musical sound, in any way, in the neighborhood of the plate A, — for convenience of operation, through the speaking-tube E, — and to let the duration of the sound signify the dot or dash of the Morse alphabet, and for the operator who receives his message (say at M) to listen to his telephone, preferably through the speaking-tube E. When two or more musical signals are being transmitted over the same circuit, all the telephones reproduce the signals for all the messages; but as the signals for each message differ in pitch from those for the other messages, it is easy for an operator to fix his attention upon one message and ignore the others.

When a large number of despatches are being simultaneously transmitted, it will be advisable for the operator to listen to his telephone through a resonator, which will re-enforce to his ear the signals which he desires to observe. In this way he is enabled to direct his attention to the signals for any given message without

being distracted or disturbed by the signals for any other messages that may be passing over the line at the time.

The musical signals, if preferred, can be automatically received by means of a resonator, one end of which is closed by a membrane, which vibrates only when the note with which the resonator is in unison is emitted by the receiving-telephone. The vibrations of the membrane may be made to operate a circuit-breaker, which will actuate a Morse sounder or a telegraphic recording or registering apparatus.

One form of vibratory circuit-breaker which may be used for this purpose I have described in Letters Patent No. 176,399, June 6, 1876. Hence, by this plan the simultaneous transmission of a number of telegraphic messages over a single circuit in the same or in both directions, with a single main battery for the whole circuit and a single telephone at each station, is rendered practicable. This is of great advantage in this: that for the conveyance of several messages, or signals, or sounds over a single wire simultaneously, it is no longer necessary to have separate instruments correspondingly tuned for each given sound, which plan requires nice adjustment of the corresponding instruments, while the present improvement admits of a single instrument at each station; or if, for convenience, several are employed, they are all alike in construction, and need not be adjusted or tuned to particular pitches.

Whatever sound is made in the neighborhood of any telephone — say at J, Fig. 4 — is echoed in fac-simile by the telephones of all the other stations upon the circuit; hence this plan is also adapted for the use of the transmitting intelligibly the exact sounds of articulate speech. To convey an articulate message it is only necessary for an operator to speak in the neighborhood of his telephone, preferable through the tube E, and for another operator at a distant station upon the same circuit to listen to the telephone at that station. If two persons speak simultaneously in the neighborhood of the same or different telephones, the utterances of the two speakers are reproduced simultaneously by all the other telephones on the same circuit; hence, by this plan, a number of vocal messages may be transmitted simultaneously on the same circuit in either or both directions. All the effects noted above may be produced by the

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same instruments without a battery by rendering the central bar F H permanently magnetic. Another form of telephone, for use without a battery, is shown in Fig. 5, in which O is a compound permanent magnet, to the poles of which are affixed poll-pieces of soft iron, P Q, surrounded by helices of insulated wire, R S.

Fig. 6 illustrates the arrangement upon circuits of similar instruments to that shown in Fig. 5.

In lieu of the plate A in above figures, iron or steel reeds of definite pitch may be placed in front of the electro-magnet O, and, in connection with a series of such instruments of different pitches, an arrangement upon circuit may be employed similar to that shown in my patent No. 174,465, and illustrated in Fig. 6 of Sheet 2 in said patent. The battery, of course, may be omitted.

This invention is not limited to the use of iron or steel, but includes within its scope any material capable of inductive action.

The essential feature of the invention consists in the armature of the receiving instrument being vibrated by the varying attraction of the electro-magnet, so as to vibrate the air in vicinity thereof in the same manner as the air is vibrated at the other end by the production of the sound. It is therefore by no means necessary or essential that the transmitting instrument should be of the same construction as the receiving instrument. Any instrument receiving and transmitting the impression of agitated air may be used as the transmitter, although for convenience, and for reciprocal communication, I prefer to use like instruments at either end of an electrical wire. I have heretofore described and exhibited such other means of transmitting sound, as will be seen by reference to the Proceedings of the American Academy of Arts and Sciences, Volume XII.

For convenience, I prefer to apply to each instrument a call-bell. This may be arranged so as to ring, first, when the main circuit is opened; second, when the bar F comes into contact with the plate A. The first is done to call attention; the second indicates when it is necessary to readjust the magnet, for it is important that the distance of the magnet from the plate should be as little as possible, without, however, being in contact. I have also found that the electrical undulations produced upon the main line by the vibration of the plate A are intensified by placing the coil G at the end of the

bar F nearest the plate A, and not extend it beyond the middle, or thereabout.

Having thus described my invention, what I claim and desire to secure by Letters Patent, is —

1. The union upon and by means of an electric circuit of two or more instruments, constructed for operation substantially as herein shown and described, so that if motion of any kind or form be produced in any way in the armature of any one of the said instruments, the armatures of all the other instruments upon the same circuit will be moved in like manner and form, and if such motion be produced in the former by sound, like sound will be produced by the motion of the latter.

2. In a system of electric telegraphy or telephony, consisting of transmitting and receiving instruments united upon an electric circuit, the production, in the armature of each receiving-instrument, of any given motion by subjecting said armature to an attraction varying in intensity, however such variation may be produced in the magnet; and hence I claim the production of any given sound or sounds from the armature of the receiving instrument by subjecting said armature to an attraction varying in intensity, in such manner as to throw the armature into that form of vibration that characterizes the given sound or sounds.

3. The combination, with an electro-magnet, of a plate of iron or steel, or other material capable of inductive action, which can be thrown into vibration by the movement of surrounding air or by the attraction of a magnet.

4. In combination with a plate and electro-magnet, as before claimed, the means herein described, or their mechanical equivalents, of adjusting the relative position of the two so that, without touching, they may be set as closely together as possible.

5. The formation, in an electric telephone such as herein shown and described, of a magnet with a coil upon the end or ends of the magnet nearest the plate.

6. The combination, with an electric telephone such as described, of a sounding-box, substantially as herein shown and set forth.

7. In combination with an electric telephone, as herein described,

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the employment of a speaking or hearing tube for conveying sounds to or from the telephone, substantially as set forth.

8. In a system of electric telephony, the combination of a permanent magnet with a plate of iron or steel, or other material capable of inductive action, with coils upon the end or ends of said magnet nearest the plate, substantially as set forth.

In testimony whereof I have hereunto signed my name this 13th day of January, A. D. 1877.

A. GRAHAM BELL.

Witnesses:

HENRY R. ELLIOTT,
EWELL A. DICK.

3981

## EXHIBIT ASSIGNMENTS, C. H. S., EXAMINER.

### BELL TO HUBBARD.

### Assignment of Patent Right.

**Liber R[21], p. 399.**

*To all whom it may concern:*

Whereas, Alexander Graham Bell, of Boston, in the county of Suffolk and State of Massachusetts, did obtain three several Letters Patent of the United States, for an improved system of telegraphy, telephony and telephonic apparatus, which Letters Patent bear date respectively, March seventh, A. D. eighteen hundred and seventy-six, and numbered 174,465, June sixth, A. D. eighteen hundred and seventy-six, and numbered 178,399 and January thirteith, A. D. eighteen hundred and seventy seven, and numbered 186,787.

And whereas, Gardiner G. Hubbard, of Cambridge, in the county of Middlesex and State of Massachusetts, trustee, is desirous of acquiring an interest therein; now this indenture witnesseth that for a valuable consideration, viz., one dollar and other valuable consideration to me in hand paid, the receipt of which is hereby acknowledged, I have assigned, sold and set over, and by these presents do assign, sell and set over unto the said Gardiner G. Hubbard, trustee, all the right, title and interest I have in the above-described invention, as secured to me by Letters Patent, for, to and in the United States and Territories, and in no other place or places. The same to be held and enjoyed by the said Gardiner G. Hubbard, trustee, for his own use and behoof, and for the use and behoof of his legal representatives, to the full end of the term for which said letters were granted, as fully and entirely as the same would have been held and enjoyed by me had this assignment and sale not been made.

In testimony whereof, I have hereunto set my hand and affixed my seal this day of July, in the year of our Lord one thousand eight hundred and seventy-seven.

ALEXANDER GRAHAM BELL. [SEAL]

Sealed and delivered in presence of

CHAS. EUSTIS HUBBARD.

Recorded July 28, 1877.

## HUBBARD TO BELL TELEPHONE COMPANY.

### ASSIGNMENT OF PATENT RIGHT.

**Liber Y[22], p. 460.**

*To all whom it may concern:*

Whereas, Alexander Graham Bell, of Salem, Massachusetts, as assignor to himself, Thomas Sanders and Gardiner G. Hubbard, did obtain Letters Patent of the United States, bearing date April 6, 1875, and numbered 161,739, and whereas said Alexander Graham Bell did obtain Letters Patent of the United States, bearing date March 7, 1876, and numbered 174,465, bearing date June 6, 1876, and numbered 178,399, and bearing date Jan. 30, 1877, and numbered 186,787, all of said Letters Patent being for improvements in "Telegraphy, Telephony and Telephonic Apparatus" invented by said Alexander Graham Bell; and whereas all of said Letters Patent have been assigned to Gardiner G. Hubbard, trustee, said letters numbered 161,739, by deed of assignment, delivered July 9, 1877, and recorded in Liber T[21], page 448 of Transfers of Patents; and said letters numbered 174,465, 178,399 and 186,787, by deed of assignment, delivered July 9, 1877, and recorded Liber R, page 399 of Transfers of Patents; and said Hubbard, trustee, is now the owner of the above-described inventions secured by said Letters Patent; and whereas the Bell Telephone Company, a corporation duly established under the laws of the Commonwealth of Massachusetts, and located at Boston, is desirous of acquiring the ownership of said inventions secured by said Letters Patent.

Now, this indenture witnesseth that I, Gardiner G. Hubbard, trustee, in consideration of one dollar and other valuable consideration to me in hand paid by said Bell Telephone Company, the receipt whereof is hereby acknowledged, have assigned, sold and set over, and by these presents do assign, sell and set over unto the said Bell Telephone Company all my right, title and interest in the above-described inventions and in and to said Letters Patent, each and all of them, the same to be held and enjoyed by the said Bell Telephone Company for its own use and behoof, and for the use and behoof of its legal representatives, to the full end of the term for which said letters were granted, and any extension or reissue there-

of, as fully and entirely as the same would have been held and enjoyed by me had this assignment and sale not been made.

In testimony whereof, I have hereunto set my hand and seal this twentieth day of July, in the year eighteen hundred and seventy-eight, being thereto duly authorized.

GARDINER G. HUBBARD, *Trustee.* [SEAL]

In presence of
C. E. HUBBARD,
R. W. DEVONSHIRE.

Recorded Oct. 3, 1878.

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BELL TELEPHONE CO. TO AMERICAN BELL TELEPHONE CO.

**Liber I[15], p. 282.**

*Know all men by these presents:*

That the Bell Telephone Company, a corporation established under the laws of the Commonwealth of Massachusetts, in consideration of one dollar, to it paid by the American Bell Telephone Company, a corporation established under the laws of said Commonwealth, the receipt whereof is hereby acknowledged, does hereby grant and convey unto said American Bell Telephone Company the exclusive right, under the following patents, to all the territory of the United States except the State of Massachusetts, viz.: Letters Patent No. 174,465, issued March 7, 1876, to Alexander Graham Bell, for an improvement in telegraphy, and Letters Patent No. 186,787, issued January 30, 1877, to said Alexander Graham Bell, for an improvement in electric telegraphy, and in and to the inventions therein described or intended to be described. To have and to hold the same to the said American Bell Telephone Company, its successors and assigns, to their own use and behoof forever. This instrument is made at the request of the National Bell Telephone Company, in pursuance of an agreement between said Bell Telephone Company and said National Bell Telephone Company, dated March 20, 1879, said American Bell Telephone Company being the appointees of said National Bell Telephone Company to receive this conveyance, and in

pursuance of an agreement between said National Bell Telephone Company and said American Bell Telephone Company, dated May 8, 1880.

In witness whereof, said Bell Telephone Company has caused its corporate seal to be hereto affixed, and these presents to be signed in its name and behalf, by William H. Forbes, its President, and William R. Driver, its Treasurer, thereto duly authorized this twenty-second day of June, A. D. 1880.

THE BELL TELEPHONE COMPANY.

L. S. Bell Telephone Company, Incorporated 1878.

By W. H. FORBES, *Prest.*

WM. R. DRIVER, *Treas.*

Recorded June 24, 1880. *Ex'd, S. P. P., H. M. L.*

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LICENSE.—HUBBARD TO NEW ENGLAND TELEPHONE COMPANY.

*Know all men by these presents,*

That whereas Gardiner G. Hubbard, of Cambridge, Massachusetts, as trustee for the Bell Telephone Company, under a declaration of trust dated July 9, 1877, owns the followi g patents of the United States:—

No. 161,739, dated April 6, 1875, granted to Alexander Graham Bell, assignor, to himself and Thomas Sanders and Gardiner G. Hubbard, for "Improvement in Transmitters and Receivers for Electric Telegraphy."

No. 174,465, dated March 7, 1876, to Alexander Graham Bell, for "Improvement in Telegraphy."

No. 178,399, dated June 6, 1876, to Alexander Graham Bell, for "Improvement in Telephonic Telegraph Receivers"; and

No. 166,787, dated January 30, 1877, to Alexander Graham Bell, for "Improvement in Electric Telegraphy" and the inventions therein described or intended so to be, and expects also the right to acquire the right to use other inventions and improvements relating to telephony and telephonic apparatus.

And whereas, The New England Telephone Company has been organized for the purpose of carrying on the business of manufac-

turing and vending telephones, and constructing lines of telegraph therefor, in the New England States,

Now, therefore, the said Gardiner G. Hubbard, trustee, in consideration of one dollar, and other valuable considerations to him paid by the New England Telephone Company, hereby conveys and will convey to the said New England Telephone Company the following interest, or so much of the same as he now or at any time hereafter may own or have power to convey, acting as trustee as aforesaid, to wit: The full, free and exclusive license to use, and to license others to use said inventions, and all patents issued, or to be issued thereon, and all reissues and extensions thereof, and a license to make the patented articles, to be used only in the New England States, to wit: Maine, New Hampshire, Vermont, Massachusetts, Rhode Island and Connecticut, together with all other rights and privileges which said Hubbard or his successors in said trust, or said Bell Telephone Company or its successors, may own, control, or have the power to grant, so far as may be needed to enable said New England Telephone Company, its successors and assigns, to enjoy said granted right within said territory as fully, freely and beneficially as said Hubbard or said Bell Telephone Company or his or its successors could have done had this conveyance not been made.

In witness whereof, I, the said Gardiner G. Hubbard, trustee, thereto duly authorized, have hereunto set my hand and seal this second day of February, 1878.

(Signed) GARDINER G. HUBBARD, [SEAL]
*Trustee.*

Witness:
(Signed) R. W. DEVONSHIRE.
(Signed) G. V. LADD.

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LICENSE — N. E. TELEPHONE CO. TO AMERICAN BELL TELEPHONE CO.

The New England Telephone Company, a corporation established under the laws of Massachusetts, in consideration of one dollar to it paid, the receipt whereof is hereby acknowledged, and in pursuance of agreements heretofore made between the parties, hath licensed and doth hereby license the American Bell Telephone Company, a

corporation established under said laws, to use and to license others to use the inventions covered by the patents granted to Alexander Graham Bell, No. 174,465, March 7, 1876, and No. 186,787, Jan. 30, 1877, and among other things to make and license others to make the telephonic apparatus therein described.

In witness whereof the said New England Telephone Company has caused these Presents to be signed in its name and behalf by Thomas Sanders, its President, and its corporate seal to be hereto affixed this sixth day of July, A. D. 1880.

THE NEW ENGLAND TELEPHONE CO. [SEAL]

*By its President*, THOMAS SANDERS.

In presence of

W. P. MONTAGUE.

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**"EATON TELEPHONE COMPANY'S CIRCULAR," CHAS. H. SWAN, EX'R.**

## TELEPHONES.

THE EATON TELEPHONE COMPANY

IS NOW PREPARED TO FURNISH TO THE PUBLIC THE WELL KNOWN

MAGNETIC AND VOLTAIC TRANSMITTING TELEPHONES,

MANUFACTURED UNDER THE DIFFERENT PATENTS ORIGINALLY ISSUED TO

*PROF. A. K. EATON, OF BROOKLYN, N. Y.*

☞ These instruments are guaranteed to be unexcelled by any in use and less liable to get out of order.

**PRICES:**

Magneto Telephones, Vulcanite Cases, $12.50 Each.
Voltaic Transmitters, Metal Cases, $15.00 Each.
Call Bell and Combined Switch, $5.00.
Batteries Per Cell, $1.60 a $2.50.

WE FURNISH AT TRADE PRICES:

*Magneto Signal Calls, Line and Office Wire, Connecting Cords, Batteries, Insulators and Brackets, Chemicals, &c.*

Every Transmitter requires one Gravity Battery, or its equivalent. The number required for signaling through the line depends upon the length, varying from 2 to 12 cells for ordinary lines.

A liberal discount allowed to companies or individuals engaged in the establishment of "Central Offices," or otherwise, requiring a large number of instruments.

ADDRESS ALL ORDERS TO

EATON TELEPHONE COMPANY, 65 HENRY ST., BROOKLYN, N. Y.

*Where the Manufactory is located.*

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# EVIDENCE FOR DEFENDANTS.

TAKEN PURSUANT TO THE SIXTY-SEVENTH RULE OF THE SUPREME COURT OF THE UNITED STATES, IN EQUITY, AS AMENDED, BEFORE ME,

JOSEPH GUTMAN, *Examiner.*

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NEW YORK, April 25, 1881.

Present: CHARLES W. WEST, Esq., *and*
FREDERIC H. BETTS, Esq., *of Counsel for Defendants:*
JAMES J. STORROW, Esq., *of Counsel for Complainants.*

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It is hereby stipulated and agreed that the depositions of William M. Goodridge, Elisha Gray and Edward S Renwick, taken in the case of the Bell Telephone Company *v.* Dowd, together with the exhibits therein referred to, shall be considered as duly taken and put in evidence in the above-entitled causes, and printed copies thereof may be filed herein, with the same effect as the originals; the complainants to have the like liberty to put in other parts of said record.

The defendants offer in evidence the following patents and publications, and certified copies of papers: —

A printed publication in the German language, entitled "Jahres-Bericht des Physikalischen-Vereins, zu Frankfurt am Main," printed and published in 1862, particularly at pages 57 to 64, which is marked "Exhibit Reis Article."

A printed publication in the German language, entitled "Zeitschrift

des Deutsch-Oesterreichischen Telegraphen-Vereins," Vol. IX., printed and published in 1862, particularly at pages 125 to 130, which is marked "Exhibit Reis-Leggat Article."

A printed publication in the German language, entitled "Die Neueren Apparate der Akustik, von Dr. Prof. Fr. Jos. Pisco," printed and published in 1865, particularly at pages 96 to 103, which is marked "Exhibit Reis Pisco Article."

It is admitted by counsel for the complainants that the said publications were printed and published at the several dates above specified as the dates of publication.

Also a certain publication, entitled "Du Moncel's Work on the Microphone and Phonograph," published in 1879, at page 165.

The defendants also offer in evidence the exhibits in the Dowd case, as the same appear on pages 66, 67 and 68 of the Dowd record, Part 1.

The defendants also offer in evidence the deposition of William M. Goodridge, Elisha Gray and Edward S. Renwick, as the same appear in said Dowd record.

Attest: JOSEPH GUTMAN, Jr., *Examiner.*

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## DEPOSITION OF HENRY MORTON.

*Direct Examination by* FREDERIC H. BETTS, Esq., *of Counsel for Defendants.*

NEW YORK, April 25, 1881.

*Int.* 1. What is your name, age, residence, and profession?

*Ans.* My name is Henry Morton; I am forty-four years of age; I reside in Hoboken, N. J., and am president of the Stevens Institute of Technology, located in that place.

*Int.* 2. What special attention have you given to the subject of electricity and electrical apparatus, and particularly to the art of telephonic transmission of sounds, and how long have you been familiar with the latter subject matter?

*Ans.* For more than twenty years I have had in my possession and in very frequent use a great variety of electrical apparatus, having employed the same in electrical experiments for my own

information, and for the illustration of lectures and other instruction given to students. I have been familiar with the experiments made by Mr. Gray, in New York, in 1874 and 1875, and since then have followed the subject both by reading and witnessing the experiments of others, and by making numerous experiments myself in various forms of telephone apparatus. My familiarity with the subject of telephonic transmission of sound dates from a visit paid me by Mr. Gray, which I think was in 1874, when he told me of his animal-tissue receiver, and invited me to witness some experiments made with it in the building of the Western Union Telegraph Company, in New York, where I called one day and saw the apparatus. About a year later Mr. Gray called again, and in response to his invitation I went again to the Western Union building, and witnessed some experiments with a multiple-tone transmitter, and tuned-bar receiver, and some other forms. From that time to the present I have interested myself in this matter, and have been familiar with the various experiments made by Mr. Bell, Mr. Edison and several others.

*Int.* 3. Have you examined and do you understand the Letters Patent granted to Alexander Graham Bell, for improvement in telegraphy, dated March 7, 1876, No. 174,465?

*Ans.* I have, and I believe that I do.

*Int.* 4. Do you find in said Bell patent, No. 174,465, any description of the transmission of articulate speech, or any apparatus capable of transmitting and reproducing articulate speech to such a degree that connected conversations could be carried on between two separated stations?

*Ans.* I do not. In reference to the first part of your question, the nearest approach to anything having even a remote connection with articulate speech, contained in the patent, are the two following: In the body of the patent the following paragraph: "One of the ways in which the armature *c*, Fig. 5, may be set in vibration has been stated above to be by wind. Another mode is shown in Fig. 7, whereby motion can be imparted to the armature by the human voice, or by means of a musical instrument." Again, in the fifth claim of the said patent I find, "The method of, and apparatus for, transmitting vocal or other sounds telegraphically as herein described by causing electrical undulations, similar in form to the vibrations

of the air accompanying the said vocal or other sounds, substantially as set forth." In the first of these paragraphs it is manifest that the human voice is suggested as a means for producing vibrations otherwise secured by the wind or by a musical instrument; and this manifestly suggests simply the use of the human voice in singing, which would produce effects like those developed by the wind or a musical instrument, and contains no suggestion of its employment in articulation, which would be entirely different from anything producible by the other parallel instrumentalities. So, likewise, in the claim, the expression "vocal or other sounds" would not suggest any other than the vocal sounds produced in singing. In reference to the instrument described, I do not think that anything shown in the patent would be capable of use in carrying on a connected conversation between two distant stations; though I do not doubt that individual words, especially when of a familiar character, could be transmitted by the use of the apparatus shown in Fig. 7.

*Int.* 5. Have you examined the transmitting and receiving instruments of the defendants, and have you read the evidence of Professor Cross on behalf of the complainants in relation thereto, and do you understand their construction and mode of operation?

*Ans.* I have examined these instruments, and understand their mode of operation; and have also read the deposition of Professor Cross, and believe that I understand it.

*Int.* 6. Have you read the evidence of William M. Goodridge and Elisha Gray, which have been introduced in this case by stipulation from the case of "The Bell Telephone Company *v.* Dowd," and do you understand the same and the exhibits therein described and referred to?

*Ans.* I have, and I believe that I do.

*Int.* 7. Have you examined the following publications relating to the Reis Telephone: "The Journal of the Physical Society," Frankfort-on-the-Maine; "Journal of the German-Austrian Telegraph Association," Vol. 9, page 125, 1862, and "Pisco's Acoustic Apparatus," of which the German titles are as follows: "Zeitschrift des Deutsch Oesterreichischen Telegraphen-Vereins," "Jahres-Bericht des Physikalischen-Vereins zu Frankfurt am Main," "Die Neueren Apparate der Akustik von Dr. Prof. Fr. Jos. Pisco," and do you

understand the construction and mode of operation of the several forms of apparatus therein shown, and have you had constructed and tested the same?

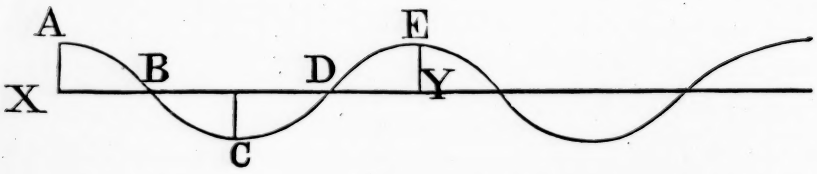
*Ans.* I have examined these descriptions, having caused them to be translated for me by one of my assistants, who is a thorough German scholar, and have made experiments with a number of the forms of apparatus there described, which I have had constructed, and believe that I understand their construction and mode of operation.

*Int.* 8. Please describe in detail the mode of operation of the Reis transmitting instruments, when constructed and used in accordance with the description in the publications above referred to. Please illustrate your description, if necessary, by diagrams, and explain the capacity and the limitations of the capacity of said Reis telephones in transmitting different kinds and qualities of sound.

*Ans.* Although the general principle and mode of action is the same in the three different forms of transmitter described and shown in the works referred to, the difference in detail is such that it would be difficult to make one description fit them all without some prolixity or a lack of clearness. I will therefore take them up in succession.

[*Any descriptions of the instruments by the witness is objected to, on the grounds that descriptions given in the extracts referred to in the question speak for themselves; and also because it does not appear that the witness has any knowledge of the construction and mode of operation of the instruments, except such as he has derived from said descriptions, and also because it does not appear that the instruments referred to by the question or by the witness were ever constructed or used in the United States prior to the granting of the two Bell patents sued on, nor prior to the invention by said A. G. Bell of the inventions set forth and claimed in the said two patents, and particularly referred to in the claims mentioned in the evidence in chief of the deposition of Mr. Cross for the complainants.*]

The first form of transmitter whose operation I will now describe is the one shown in Pisco's work, page 94, and represented in the accompanying wood-cut.




In this apparatus, when sound waves are caused to enter the box of the transmitter through the projecting mouthpiece S, they produce successive condensations and rarefactions in the contained air, by which the membrane *m m* is pushed up or drawn down. As the membrane is pushed up, it begins by increasing the contact pressure between the platinum electrode *s*, connected with the positive pole of the battery, which is attached to the centre of the membrane, and the other electrode, projecting downwards from the right-angled piece *a b*, connected with the other pole of the battery, through the line and receiving instrument. (All these smaller parts are best shown in the enlarged drawing at the right of the figure.) As the upward movement begins, it produces, as I have said, an increase of pressure between the electrodes, and this increased pressure will, by decreasing the resistance, produce an increased flow of the electric current through the circuit, and this increase will vary with the variation of pressure produced between the electrodes, which again will depend upon the varying velocity with which the diaphragm moves upward, and the inertia of the right-angled piece which carries the upper electrode. Suppose this upward motion of the diaphragm to correspond with that of an ordinary sound wave, or to be like a pendulum swing, beginning with the middle point of the vibration: then the upward motion would be most rapid at first, and would gradually die out, reaching a state of rest when the diaphragm had moved up to the highest point of its displacement. During this time the pressure between the electrodes, greatest at the outset, would be gradually diminishing through the loss of motion of the diaphragm, and gain of motion by the upper electrode. It would therefore produce a fluctuation of the electric current, which would be represented by the descending half of a positive wave; that is, by such a line as *a b* in the accompanying diagram,

where $x\ y$ represents the line of normal current when everything is at rest, and the distances above this line represent amounts of current greater, and distances below this line represent amounts of current less than this normal quaantity. Having reached the uppermost part of its motion, the diaphragm would begin to descend with increasing velocity, in obedience to the reverse motion of the sound wave as well as to other causes, which would manifestly diminish the pressure between the electrodes; and this motion, being at first slow, would become more rapid, and then in turn slacken. When this motion reached its greatest rapidity, we should have the least pressure between the electrodes, and this would correspond to the point $c$ on the diagram, and to the time of one quarter sound wave from $b$. As the downward motion slackened, the pressure between the electrodes would increase until the diaphragm came again to rest at the lowest point of its motion, when we should have the normal pressure restored, and this would correspond to the point $d$ in the diaphragm. The membrane would now begin to ascend again, in obedience to the impulse of the sound wave, with an increasing velocity, which would reach its maximum when the membrane had made a motion corresponding to another quarter wave, and at this moment the pressure between the electrodes would be at a maximum, indicated by the line $e\ e'$, which, evidently, corresponds with the height $a\ x$, which I assumed at the beginning for a starting point, but which would evidently have been reached by the motion of a previous vibration, such as we have considered as terminating this one. Now, it is manifest that the exact contour of this wave will be modified by several forces, besides the mere movement of the diaphragm, in obedience to the sound wave, the elasticity of the diaphragm and the inertia and momentum of the upper electrode and its connected right-angled piece will be the most important factors; but admitting all this, it is manifest that an undulatory current, corresponding in a greater or less degree of exactness with the undulations of the sound wave, will be developed, provided that the motions of the diaphragm are not so violent as to rupture contact between the electrodes by throwing the upper one upwards with so much force that it either leaves the diaphragm

or fails to follow it in its downward movement. I have so far considered only a single sound wave; but it is manifest that what is true of one wave would be true of another, and that whatever resultant motion took place in the diaphragm from the combined action of several sets of waves of different lengths would produce corresponding fluctuations of current with greater or less accuracy.

It is thus manifest that from general principles we could deduce the probability that this apparatus, so used as not to produce too violent motions of the diaphragm, would be able to transmit not only electric undulations corresponding to single musical notes, but also chords, and even those complex inflections involved in the vibrations constituting articulate words.

I have in fact found that this instrument, when spoken to in such a manner as to avoid a too violent vibration, will produce fluctuations in an electric current, which, when transformed into sound waves at a distant station by any appropriate telephone receiver, are readily recognized, and have all the characteristics of articulation.

I have in this manner heard not only single words, but short sentences, many of which I was in no respect prepared to anticipate. The sound produced at the receiving station is in this case not loud; and in order that with this instrument sound should be produced so loud as to be audible to a number of persons at once, a vibration must be given to the membrane so violent as to produce ruptures of contact. And then we are confined, as far as my experience goes, to the reproduction of single successive notes.

In reference to the other forms of the Reis transmitter, such as the cubical referred to in the Frankfort "Journal," and the cone form shown in the *Legat* article, cuts of which are here introduced, the explanation which I have given would in all essential particulars apply to them, substituting, however, the elasticity of springs and the inertia of a lever *d e c* in the latter case for the weight and inertia of the upper electrode *a b* in the apparatus first described.

In my own experiments I found these forms less easy to adjust and operate than that first mentioned, but with both of them I have occasionally obtained distinct articulation, accompanied by the peculiar and characteristic sound of the human voice.

[*Adjourned.*]

APRIL 26, 1881.

[*The witness asks to state that in looking over his answer to Int.* 4 *he observes that there is another place in the Bell patent, No.* 174,465, *besides the two already mentioned by him, where the use of the voice in connection with the apparatus is alluded to; namely, in the paragraph immediately succeeding that first quoted, and beginning "The armature* c, *Fig.* 7," *he finds as follows: "When a sound is uttered in the cone, the membrane* a *is set in vibration." And again, at the end of the same paragraph, "a similar sound to that uttered into A is then heard to proceed from L." In this, as in the instances before cited, there is nothing which implies that the sound uttered was of an articulate character, or, in other words, anything but what is equally produced by a musical instrument, or the human voice in singing.*]

*Int.* 9. Please state whether you tried the several forms of Reis instrument, described in the publications here referred to, with reference to their capacity to transmit and reproduce music or musical tones or notes; and if so, with what results.

*Ans.* I tried all of these instruments, and found that they would all transmit musical notes produced by singing with even greater facility than articulate speech. In other words, it was not necessary to have so careful an adjustment, or to be as careful in modulating the voice when singing as when uttering words.

*Int.* 10. I notice in the several publications relating to the Reis instrument, referred to by you, that the instrument is described as operating by opening and closing the electric circuit: will you please state what you understand to be the meaning of that, and in what sense, if at all, the same is true?

[*Objected to on the grounds that the publications speak for themselves.*]

*Ans.* The primary object of those experimenting with the Reis telephone at its first development was to produce at the receiving station sounds loud enough to be perceived by a number of persons at once, and who were hence at some little distance from the instruments. To effect this, it is manifestly necessary to effect a very powerful movement in the receiver, and with such an instrument as the Reis transmitter this could only be accomplished by causing

the membrane to vibrate in such a way as to cause interruptions in the circuit. It thus happened that the instrument, as so used, did undoubtedly operate essentially by producing an intermittent or pulsatory current.

It was thus natural for any writing about this instrument to describe it as operating by an interrupted current, even though on certain occasions it could and did transmit a current with undulations of intensity and without interruptions. I recognize the naturalness of this because I know that when writing of my own experiments with a modification of the Reis instrument, I always spoke of it as operating by an interrupted current, though perfectly well aware that it would also operate without rupture of circuit. In this case, however, the sound produced was too faint to be of any value for the object aimed at, which was a loud-sounding telephone to be employed as an illustration in public lectures.

*Int.* 11. Please state whether the Reis instruments, when constructed as described in said publications, even when operated by sounds so loud as to produce from time to time actual interruptions of the current, do operate also by means of a fluctuating current, or one which varies in accordance with the sounds operating upon the instrument.

[*Question objected to as vague and ambiguous in form and immaterial in substance.*]

*Ans.* Under the conditions you mention, the apparatus would undoubtedly be operated in part by means of a fluctuating current or one varying in accordance with the sounds acting on the instrument; but to how great a degree this would render them practically efficient would depend upon the frequency of such interruptions.

*Int.* 12. Do you know whether the complainants, the American Bell Telephone Company, commonly use any form of transmitting instrument shown or described in the Bell patent, No. 174,465? And if not, state what form of transmitting instrument is now commonly used by them.

*Ans.* The instrument commonly used at the present time as a transmitter by the Bell Telephone Company is, I believe, what is known as the Blake transmitter. This is in no respect like any form of apparatus described and shown in the Bell patent, since it

produces the fluctuations of the electric current solely by contact pressure between two electrodes, and not in any way by the inductive influence of a magnetic body moving in a field of magnetic force.

*Int.* 13. Please compare the apparatus and mode of operation of the Blake transmitter with the apparatus and mode of operation of the Reis instrument, above referred to by you, and state in what respects the same are substantially similar, and in what respects the same are substantially dissimilar.

*Ans.* In both instruments the powers of transmission consist in receiving the motion of sound waves upon a diaphragm in contact and connection with one of two electrodes, between which variations in pressure are produced by the motion of said diaphragm, and these changes in pressure develop corresponding fluctuations in an electric current, which, being transmitted to the other end of the line by its magnetic action, causes a retransformation of the electric current into motions of the air or sounds. In both instruments elastic diaphragms are employed; in both, platinum electrodes are in contact or connected with the centres of these; in both instruments, with the exception of one of the Reis telephones, contact between the electrodes is primarily established by the elastic force of springs, and in this excepted Reis instrument this contact is secured by the force of gravity. These are the chief points of resemblance. As to the differences, I find that in the Blake transmitter the diaphragm is of sheet iron, which, by its peculiar elasticity, has a decided advantage over the animal membrane used in the Reis instrument. Again, in the Blake transmitter, the movable electrode is made of hard carbon in place of platinum or iron, as in the Reis transmitter. This, likewise, is a decided advantage, as hard carbon possesses certain peculiar advantageous properties when thus used.

In the third place the movable electrode in the Blake transmitter has considerable weight combined with a free mode of suspension which I do not find in any form of the Reis instrument. These, I think, constitute the most important practical distinctions between the two forms of apparatus to which you draw my attention.

*Int.* 14. Please look at the instrument now shown you, and state

if that is one of the Blake transmitting instruments referred to by you.

*Ans.* It is.

[*Instrument is marked for identification, "Blake Transmitter, J. G., Jr., Ex'r."*]

*Int.* 15. Please compare the method of and apparatus for transmitting vocal or other sounds telegraphically, described and illustrated in the Bell patent, No. 174,465, with the method of and apparatus for transmitting vocal or other sounds telegraphically, embodied in the apparatus of the Reis instrument above referred to by you; and state in what respects the same are substantially similar, and in what respects the same are substantially dissimilar.

*Ans.* As regards the general method when the Reis instrument is so used as not to cause interruptions of the circuit, we have in both cases an instrument which receives pulsations or waves of sound, transforms them into undulations of electric current, which are transmitted through a wire, at whose farther end is an instrument which, receiving these electric undulations, reconverts them into the air motions, constituting sound. This double transformation is in both cases attended with more or less modification, but in both cases may leave enough resemblance between the sound obtained at the receiving station and the sound produced at the transmitting station to make recognition possible, even where so complex a sound as a spoken word is concerned. I, of course, confine my comparison to that form of apparatus represented in Fig. 7 of Mr. Bell's patent, as it is not, I believe, claimed that that shown at Fig. 5 would be operative for the transmission of speech. It appears from what I have above said, that taking simply this general view of the operation of the two forms of apparatus, this would be entirely identical in the two cases. If, however, we take up the operations in detail, we will find that while in the apparatus of the Bell patent, as well as in that of Reis, the sound waves, in the first instance, in both cases set in motion an elastic diaphragm, this motion is caused to produce a fluctuating current in the two cases in an entirely different way by entirely different means. In the Bell apparatus the moving diaphragm gives motion to what we may consider as the semi-detached armature of an electro-magnet, and the motion of this arma-

ture will in a manner more or less direct influence the strength of the current flowing through the coils surrounding the said electro-magnet. On the other hand, in the Reis apparatus, we have at the transmitting station no electro-magnet and no armature; but the motion of the diaphragm line occasions variations in pressure between two electrodes in contact, and by this means causes fluctuations in the electric current passing through these electrodes and thence to the line and distant station. Considering next the receiving instruments, it is manifest that if we compare the Bell receiver with that one of the Reis receivers shown in the *Legat* article, we shall find a very close resemblance; that is, in both we have an electro-magnet through which the undulating current passes, and opposite whose poles an armature is sustained by elastic support, to which it communicates its vibrations, produced by changes in the attractive force of the electro-magnet, developed by the fluctuations of the undulating current.

In the Bell receiver the elastic support is a membranous diaphragm, which transmits the vibrations of the armature directly to the air. In the Reis receiver the elastic support consists of certain springs and a standard, which communicate the vibrations of the armature to the air, in part directly, but mainly through the wooden base to which they are attached. In the other form of Reis receiver the action is quite different. The fluctuating current here flows through a coil surrounding a long and thin iron bar supported from a resonant wooden case; the molecular change produced in this iron bar by fluctuations in the current occasion in it vibrations which are transferred to the wooden case, and by it are given to the air.

It is therefore manifest that in the details of structure and operation there are manifest differences between these instruments, which you have desired me to compare.

*Int.* 16. Please state whether in the operation of the defendants' transmitting instrument, and in the operation of the transmitting instrument commonly used by the complainants, known as the Blake transmitter, the contact between the electrodes is a constant one; or whether such contact is ruptured or broken if sound waves, due to loud sounds, impinge on the diaphragm?

[*Objected to as indefinite and ambiguous in form and immaterial in substance.*]

*Ans.* In both cases it is my belief that the contacts are only constant so long as sounds of moderate intensity are employed. Any violent sound impulse will, I believe, occasion a rupture of contact in either case.

*Int.* 17. Please compare the defendants' transmitting instrument with the transmitting instruments of Reis above referred to by you, and also with the transmitting instrument of Bell shown in his patent, No. 174,465, and state whether said defendants' instrument belongs to the class of instruments of Reis, or that of Bell, in its construction and mode of operation?

[*Same objections.*]

*Ans.* I find the transmitting instrument of defendant to consist substantially of a vibrating metallic diaphragm, in contact with which is supported a platinum electrode, kept in elastic contact with a carbon electrode by means of a spring and elastic sleeve of rubber. Electric connection is made with these electrodes through the primary circuit of an induction coil, and when the apparatus is operated by talking to the diaphragm, its vibrations produce variations in pressure between the electrodes in contact, and thus occasion fluctuations in the current. These fluctuations in the current through the primary circuit of the induction coil occasion corresponding currents, known as induced currents, in the secondary circuit of this same coil, and these being carried to an appropriate receiver, they reproduce with sufficient accuracy the original sounds. In these respects, this apparatus, in its general features, corresponds exactly with the Blake transmitter, in which, as in this instrument, an induction coil is employed as an intermediate step in the transmission of the fluctuating current.

This reminds me that in my previous allusion to the Blake instrument, I inadvertently omitted mention of the induction coil, whose action was not involved in the discus-ion of its action I was then making; nor is it, indeed, of any importance as regards its general principle. Comparing defendants' transmitter, in the next place, with the Reis transmitter, I find that in this case, also, we have an elastic diaphragm carrying one electrode, against which the other

electrode is held in elastic or yielding contact by a spring or by gravity, and that in the operation of the instrument, the sound vibrations, acting on the diaphragm, cause changes in pressure between the electrodes, which changes in pressure cause fluctuations in the current passing between them, and thence by the line to the distant station.

In regard to its general mode of operation the Reis transmitter, like the Blake transmitter, resembles the transmitter of defendants, and all three belong to the same class of what may be called microphone or varying contact transmitters, or those in which the fluctuations of the current are produced by changes in pressure between the electrodes in contact.

Comparing defendants' transmitter with that shown in the Bell patent, Fig. 7, I find it to differ in that it does not contain any electro-magnet whose armature is moved by the vibrations of the diaphragm, and thus in operation the motions given to the diaphragm by the sound waves do not produce an undulatory electric current, by reason of the inductive action exerted by such moving armature upon the current flowing through the coils of the electro-magnet and thence to the line and receiving station. I therefore consider that defendants' transmitter does not belong to the class of electro-magnetic telephones of which that represented in Fig. 7, in the Bell patent, is an example.

*Int.* 18. Please state in what respects, if any, the defendants transmitter is an improvement upon that of Reis.

*Ans.* In the use of a metallic in place of a membranous diaphragm, in the employment of a carbon electrode in place of a platinum or iron one, and in the greater massiveness and more substantial, while relatively free support of the movable electrode. Of course the induction coil is of advantage as increasing the range of action, but not as modifying the operation of other parts.

*Int.* 19. Do you find any of the improvements or modifications which render the defendants' instrument more efficient (though it belongs to the same class as Reis's instruments) to be in any way described, illustrated or suggested in the Bell patent, No. 174,465?

[*Objected to for the same reasons as above, and as assuming that it belongs to the same class as Reis's.*]

*Ans.* I do not.

*Int.* 20. Please refer to the extract from the Bell patent, No. 174,465, quoted by Prof. Cross in answer to Int. 13, and state whether you find therein contained any practical suggestion which would enable any person skilled in the art at that time to construct an instrument for transmitting articulate speech?

*Ans.* I do not. In this extract I find only the suggestion that an undulatory current might be produced by varying the resistance of a circuit in two ways: by modifying the internal resistance of a battery by varying the distance apart of the elements, or their depth of immersion; and secondly, varying the external resistance by causing a conducting wire to dip more or less deeply into a liquid which constituted part of the circuit. No mechanical arrangement for effecting any of these movements is described, nor, as I have before mentioned, is it, either here or elsewhere in the patent, suggested that articulate speech might be transmitted to a distance by any of these means. As to the variation of resistance by change in pressure between solid bodies in contact there is manifestly no suggestion whatever.

*Int.* 21. Please examine the nineteenth question and answer of Prof. Cross's deposition, and state whether the fact that it had been known before the date of Mr. Bell's patent that the resistance of an electric circuit is varied, without being broken, by variations in intimacy of contact or amount of pressure between two electrodes in contact, as stated by Prof. Cross in his said answer, would enable any persons skilled in the art, after reading Mr. Bell's said patent, No. 174,465, to construct an instrument for practically transmitting articulate speech, in which the variations of resistance of the circuit were caused by variations in pressure between electrodes; and if not, why not.

*Ans.* I do not think that the knowledge as to the effect of pressure between electrodes in contact, which existed at the date referred to, was at all adequate to enable a skilful electrician, with Mr. Bell's patent before him, to construct an operative apparatus on the basis of that property, without experiment and invention. In the first place, the knowledge on this subject, as shown in the quotations given by Prof. Cross, was of a very limited and indefinite character.

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Thus, his first quotation simply amounts to a statement that "when surfaces were in contact, with very slight pressure, a great enfeeblement of current was experienced, possibly through the presence of rust on the surface, and possibly from some other cause." The second quotation amounts to stating that "where metallic plates were in contact with wood, the amount of pressure upon the metallic plates in communication with the wood might modify the resistance." The third extract is more explicit, and states that "with platinum and wood in contact, a great falling off of current was observed when the pressure fell from a maximum, not stated, to the weight of the platinum plate, in which last condition no current was observed to pass." The last quotation is the best as well as briefest, and is as follows: "Experience shows that the greater the pressure of contact, the greater is the strength of the current which passes." At the best, then, this would simply show us that between certain substances, one of which is practically a non-conductor, a greater current is obtained with very heavy pressures than with light ones, and that with small pressure there may be no current at all. With such knowledge as this, it would certainly be impossible to predict whether any pair of substances would ever be found which would produce by changes of pressure between them, variations in current corresponding to the sound waves producing such changes in pressure, and still less to predict whether such result could be procured by the use of any known pair of substances; because it would evidently be possible, as has since proved to be the fact, that the law of variation of resistance with changes of pressure would differ greatly with different substances, and it would, of course, also be possible that this law might in no case be such as to render this production of an undulatory current by fluctuations of pressure practically available in this connection.

[*Adjourned.*]

APRIL 27, 1881.

*Int.* 22. If at the date of the Bell patent, No. 174,465, the knowledge in regard to the effect upon an electrical current of variations of pressure between electrodes in contact was in the condition described in your last answer, why do you consider the Reis telephone as embodying the features of a fluctuating or undulatory cur-

rent corresponding to the vibrations accompanying vocal and other sounds?

*Ans.* In reply to your question, I would first state that there does not seem to be any necessary connection between the two sets of facts which it seems to unite. Thus my previous answer pointed out that the knowledge as to the effect of pressure upon resistance shown in certain extracts quoted by Prof. Cross was not sufficient to enable one, with the Bell patent before him, to construct a practically efficient speaking telephone without experiment and invention, even if we add to the knowledge conveyed by these quotations the further knowledge of the state of the art, to the effect that the Reis telephone had occasionally been known to transmit articulate speech, together with the fact that all writers on the subject described it as operating by an interrupted current. It seems to me that this would have added nothing of any avail in enabling any one to construct a speaking telephone operated by varying pressure between electrodes, with only the above-mentioned knowledge and Mr. Bell's patent to guide him.

Fully realizing all this, however, it seems to me in no wise to influence this conclusion to admit that the Reis telephone actually did embody the feature of a fluctuating or undulatory current corresponding to changes in pressure between the electrodes, produced by the air vibrations, constituting spoken words. For this feature, though it undoubtedly existed in the Reis instrument when used to transmit articulate speech, was not recognized by the authors describing it, and would therefore have furnished no information which would have enabled the supposed manufacturer to have constructed an operative telephone under the conditions above stated.

*Int.* 23. In answer to Int. 8, you spoke of using the Reis transmitting instruments in connection with "any appropriate telephone receiver." Please state with what forms of receiver you tested the Reis transmitting instruments, and what results in the case of each form of receiver. State also why the results were different, if at all, with the different forms of receiver used by you, and whether any difference in the result at the receiver indicated any difference in the method of operation of the transmitters.

*Ans.* I used in all four kinds of receivers · a Bell magneto receiver,

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a Phelps magneto receiver (either of these could also be used as transmitters), a new form of receiver described in a patent granted to A. K. Eaton, Feb. 15, 1881, No. 237,838, and a receiver made in general accordance with the description contained in Legat's article. The two first receivers acted equally well; the third gave the sounds more faintly, being less sensitive; and the last named, being very deficient in sensitiveness, would only render audible continuous sounds, like those produced in singing. There was no difference in the results obtained indicating any difference in the action of the transmitters, but only a difference in sensitiveness in the receivers.

*Int.* 24. Which material for the electrodes described by Reis produces the best results, and the closest approximation in electrical undulations or inflections to the sound vibrations producing them?

*Ans.* An iron pin or point with a platinum plate in the horizontal diaphragm form, and a brass point with a platinum plate in the horizontal cone. In the cubical block I only tried platinum electrodes.

*Int.* 25. Have you practically tried the instruments constructed as shown and described in Fig. 7 of Bell's patent No. 174,465? And if so, produce the same; and state what the results of your trials have been.

*Ans.* I here produce the model made after the drawings of the Bell patent, with the exception that the cones in both instruments flare outwards; or in other words, the two instruments, transmitter and receiver, are duplicates. On repeated trials with these, I have only been able to hear musical sounds, though it is, of course, possible that with some variation of battery current or change in the membranes, articulation might be produced with them.

*Int.* 26. Have you here the Reis instruments which have been tested by you, as you have hereinbefore testified? And if so, produce them, and state whether the same are or are not constructed faithfully in accordance with the printed publications before referred to by you.

*Ans.* I produce these exhibits, which I believe to be faithfully made, in accordance with the directions of the publications quoted.

[*Exhibits offered in evidence and marked as follows: "Defend-*

*ants' Exhibit Box Form Reis Transmitter," "Defendants' Exhibit Horizontal Cone Reis Transmitter," and "Defendants' Exhibit Cubical Block Transmitter."*]

*Int.* 27. Please state whether the improvements in the defendants' telephones, described by you, which render the same more perfect and efficient than those of Reis, required for their production invention, and whether the same were or were not known at the date of the Bell patent, No. 174,465.

*Ans.* The use of a metallic diaphragm was, I think, to a certain extent, known prior to this date through the patents and experiments of Mr. Gray. But the employment of carbon and platinum electrodes, and the use of a massive movable electrode with an elastic yet free support, was not, I think, known at that time.

*Int.* 28. Have you read Prof. Cross's description of what he considers the essential features of the Bell apparatus? And, if so, please state whether you find in the publications in reference to the Reis instrument, before referred to by you, any apparatus described and shown consisting of the following parts: —

*First.* A transmitter possessing a movable part which is capable of being set in vibration by the agency of the voice.

*Second.* This movable part so arranged that it causes electrical variations in the current traversing the line wire.

*Third.* A receiving instrument so arranged that the variations in the current referred to communicate motion to a movable part, which in its turn communicates motion to the air around it.

*Ans.* I have read this deposition of Prof. Cross, and find in each of the various publications in reference to the Reis instruments, descriptions of apparatus consisting of parts corresponding precisely to the three descriptions given by Prof. Cross: that is, in each I find described a transmitter possessing a movable part, which is capable of being set in vibration by the agency of the voice; second, this movable part so arranged that it causes electrical variations in the current traversing the line wire; third, a receiving instrument so arranged that the variations in the current referred to communicate motion to a movable part, which in its turn communicates motion to the air around it: with this only exception, that in the Reis receiver the movable part receiving motion from the varying current, while

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communicating a little of that motion directly to the air around it, communicates most of it to the air through the resonant case on which it stands.

[*Question objected to for the reason that it purports to state Mr. Cross's description of the essential features of the telephone, and that it does not state his description correctly in substance or in effect, and omits features which he treats as essential.*]

*Int.* 29. Have you read the evidence of Prof. Cross in answer to Int. 44, in regard to the microphones shown on page 165 of Du Moncel's work? In your opinion does said microphone embody the apparatus described and referred to in the fifth claim of Bell's patent, No. 174,465?

[*Question objected to on the ground that it is a question for the Court and not for the witness.*]

*Ans.* If this claim is construed as covering every form of apparatus and every method by which vocal or other sounds may be transmitted telegraphically, by causing electrical undulations similar in form to the vibrations of the air accompanying the said vocal or other sounds, whether this apparatus and these methods are substantially like those described and shown in the patent or substantially different, then this claim would undoubtedly cover the microphone; or in other words, the microphone referred to would embody the method and apparatus here claimed. But if the claim is so construed as to cover methods and apparatus substantially like those set forth in the patent, then I think the microphone transmitter would not embody that invention or any part of it.

[*Answer objected to on the ground that it is merely the witness's expression of opinion upon the question which is to be determined by the Court.*]

*Int.* 30. Have you read Int. 15 of Prof. Cross's deposition and the answer thereto? And, if so, state whether you agree or disagree with him in the opinion there expressed.

*Ans.* I have read this question and answer, and do not agree with Prof. Cross, as I consider both the apparatus and methods to be substantially different, even though the results obtained are practically alike; and therefore should say that from a scientific point of view the methods by which this result is obtained are substantially dif-

ferent, even if it should prove, as I do not think is here the case, that for practical purposes they were equivalent.

*Int.* 31. Please read the concluding sentences of the answer to the eighteenth interrogatory to Prof. Cross, commencing with the words "In my opinion," and state whether you agree or disagree with him in the said opinion.

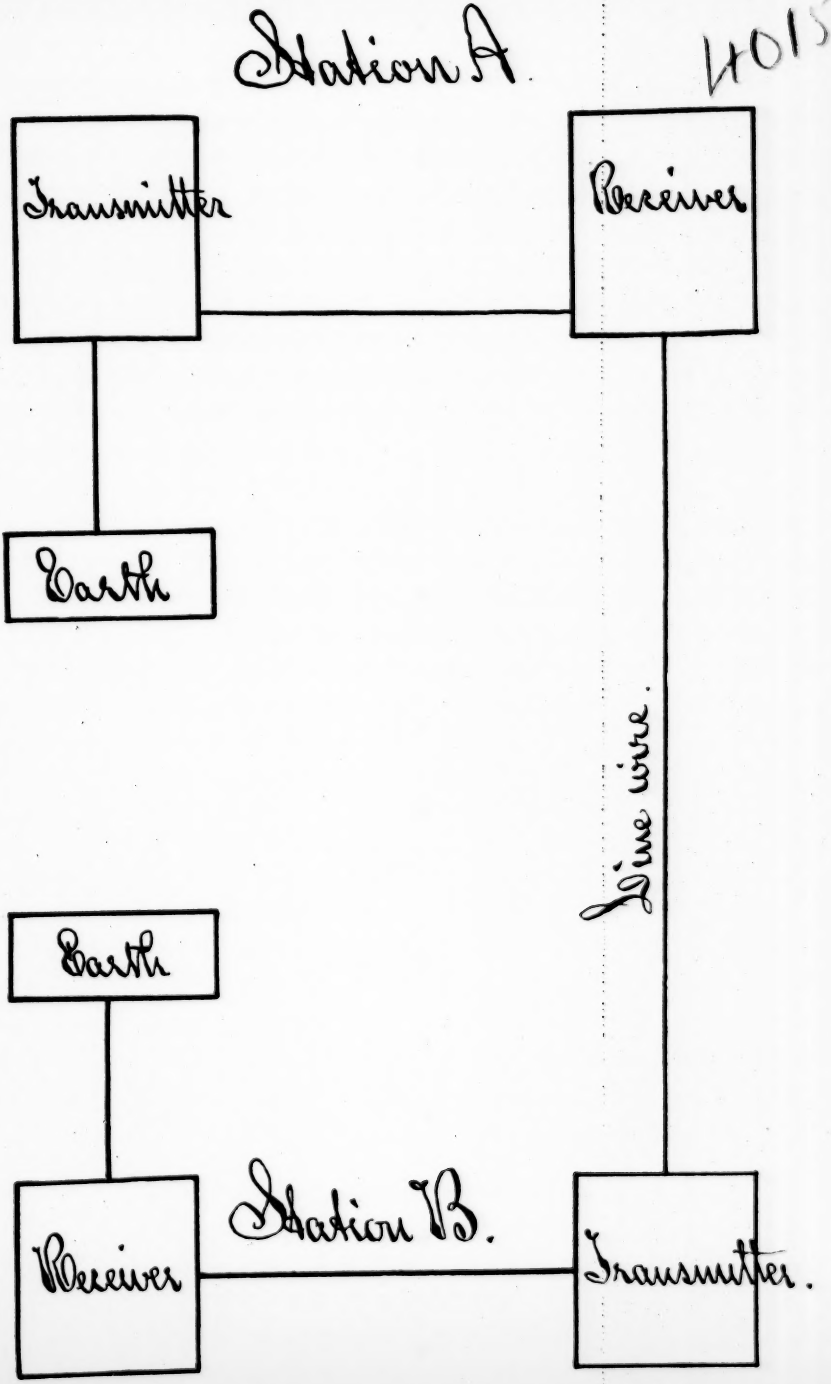
*Ans.* I have read the passage referred to, and do not agree with the opinion there expressed, for the reasons mentioned in my last answer, and also because I have observed that the adoption of this particular method of varying the resistance of the circuit, in place of the method suggested in Mr. Bell's patent, has been an essential feature in the widely extended development which has been given to the telephone system during the last few years.

*Int.* 32. Please refer to the following statement in "Journal of the German-Austrian Telegraph Association," in the article relating to the Reis telephone, by Mr. Legat, particularly at the following words, "Let me premise, however, that for the sake of clearness, the appliances connected with the apparatus for alternately transmitting and receiving have been omitted," and state whether you understand what the construction and arrangement for alternately transmitting and receiving was, and make a diagram showing the connections which you understand to be referred to by said words.

[*Question objected to, as the description speaks for itself.*]

*Ans.* I understand the arrangements described to have been as follows, and as shown in the diagram which I now make: At each station was placed a receiver and transmitter connected together, the transmitter of each station being connected with the receiver of the other, either by a wire in both cases or by a wire in one case and the earth in another. The circuit being of course always closed in the receivers, and also closed in the transmitter when not in use, it would then be possible to transmit and receive alternately without any adjustment of switches, or the use of more than one connecting wire between the stations. I put in evidence the diagram referred to as part of my answer.

*Int.* 33. Please state whether, when the Reis instruments were arranged, as referred to in said Legat article, for alternately transmitting and receiving, and when receivers like those shown in said


Station A.
Transmitter
Receiver
Earth
Line wire.
Earth
Receiver
Station B.
Transmitter.

article were thus arranged as two sections, whether the combination of parts was substantially like or unlike the apparatus shown and described in Fig. 5 of Bell's patent, No. 174,4 5, and whether the same is capable of operating in the way described by Bell in said Letters Patent.

[*Question objected to as immaterial.*]

*Ans.* When arranged as described, the receivers would show a combination of parts substantially like that shown and described in Fig. 5 of Bell's patent, and would be capable of operating in the manner described in said patent.

*Int.* 34. Please examine the first claim of said Bell patent, No. 174,465, and state whether you understand the invention therein referred to.

[*Question objected to as immaterial.*]

*Ans.* I have, and believe that I do.

*Int.* 35. Please examine also the Letters Patent granted to Thomas A. Edison, dated Aug. 12, 1873, No. 141,177, and state whether you understand the construction and mode of operation of devices therein described.

*Ans.* I have examined this patent, and believe that I understand the devices therein described.

*Int.* 36. Please compare the invention described and referred to in the first claim of Bell's patent, No. 174,465, with the said Letters Patent No. 141,777 of Edison, and state whether you find described in said Edison patent the invention described and referred to in the first claim of the said Bell patent; and give your reasons for any opinion you may express.

*Ans.* Comparing these two inventions, I find that both of them involve a system of telegraphy in which the receiver is set in vibration by the employment of undulatory currents of electricity, and that one of the ways for producing this undulatory current set forth in Mr. Bell's patent is to cause one of two electrodes to plunge to a greater or less depth in a conducting or semi-conducting liquid connected with the other, and that this is precisely the way in which the actuating current, which would manifestly be an undulatory one, is transmitted in Mr. Edison's device.

*Int.* 37. Please examine the fourth claim of said Bell patent,

No. 174,465, and state whether you understand the alleged invention therein referred to.

[*Objected to as immaterial.*]

*Ans.* I have examined this claim, and believe that I understand it.

*Int.* 38. Please state whether you find the alleged invention referred to in said fourth claim of said Bell's patent, No. 174,465, described or shown in said Edison patent, No. 141,177, and give your reasons for any opinion you may express.

*Ans.* I find the fourth claim of the Bell patent to be for the producing undulations in a continuous voltaic circuit, by gradually increasing or diminishing the resistance of the circuit, or by gradually increasing or diminishing the power of the battery. As far as the first of these methods is concerned, I find this invention described and shown in the Edison patent, as pointed out in my previous answer.

*Int.* 39. Have you examined the Letters Patent granted to A. G. Bell, dated Jan. 30, 1877, No. 186,787, and do you understand the construction and mode of operation of the instruments therein referred to?

*Ans.* I have, and believe that I do.

*Int.* 40. Please compare the invention recited in the third claim of said Letters Patent with the receiving instrument described in the article by Mr. Legat, in the "Journal of German-Austrian Telegraph Association," and state whether you find the invention represented in said third claim described or shown in said Legat article.

*Ans.* I find this third claim to be for the combination, with an electro-magnet, of a plate of iron or steel or other material capable of inductive action, which can be thrown into vibration by the movement of surrounding air or by the attraction of a magnet. This claim is as precise a description as I think it would be possible to give of the armature and magnet constituting the receiver shown in the Legat article.

*Int.* 41. Please compare the alleged invention described and referred to in the third claim of said Bell patent, No. 186,787, with the instrument described in the evidence of Elisha Gray, which has been stipulated into this case, and particularly with the instrument

shown and known as Gray's Concave Metallic Diaphragm Magnet Receiver, and state whether you find the alleged invention described in said Bell's third claim embodied in the said instrument of said Elisha Gray, and give your reasons for any opinions you may express.

*Ans.* I have compared the invention of the third claim with the instrument described by Mr. Gray, and find in this case also that the words of this claim constitute a perfectly accurate description of said instrument, which consists of an electro-magnet, with an iron plate supported opposite its poles so as to be capable of receiving a vibratory motion either from the air or from the action of the magnet.

*Int.* 42. Please examine the seventh claim of said Bell's patent, No. 186,787, and compare the alleged invention therein described and referred to with the apparatus and instruments contained and described in Bell's patent, No. 174,465, particularly in Fig. 7, and state whether you find the alleged invention described in said seventh claim of said Bell's second patent, and also shown and described in Fig. 7 of said Bell's first patent.

*Ans.* I have compared these respective descriptions, and find them to represent, as I understand, one and the same invention; namely, an enclosing tube, by which the vibration transmitted to the air by the diaphragm would be conveyed to the ear.

*Cross Examination by* JAMES J. STORROW, Esq., *of Counsel for Complainants.*

*Cross-Int.* 43. Please refer to your thirty-second answer, and point out to me that passage in the Legat article which describes the arrangement shown in the diagram which forms part of that answer.

*Ans.* There is no passage which specifically describes this arrangement; but the passage quoted in Int. 33, as I understand it, necessarily suggests to any one familiar with the arrangement of telegraphic apparatus such a connection of parts as my diagram shows. In other words, Legat shows one receiver, one transmitter, and one line wire, and says that he omits the apparatus for alternately transmitting and receiving, from which I therefore presume that he

has omitted such a duplication of the receiver and transmitter as my diagram shows, everything else remaining the same.

*Cross-Int.* 44. Is it your understanding that the illustration in the Legat article shows one station with two instruments, or two stations each with one instrnment?

*Ans.* Two stations each with one instrument.

*Cross-Int.* 45. When did you first transmit an articulate sentence with the instruments which you have put in evidence as Reis transmitters, or with any instruments made in exact accordance with the publications referred to in your seventh answer?

*Ans.* The first time I transmitted articulate sentences myself was at my own house, Monday, the 11th of April, 1881. I had, however, before this, at Morton, in Pennsylvania, heard messages transmitted, being then at the receiver, on Tuesday, March 29, 1881.

*Cross-Int.* 46. Where were these three instruments, marked "Defendants' Exhibit Box Form Reis Transmitter," "Defendants' Exhibit Horizontal Cone Reis Transmitter," and "Defendants' Exhibit Cubical Block Transmitter" constructed?

*Ans.* They were, I believe, constructed under Mr. Irwin's directions, at Morton, in the first instance, and some slight repairs and replacement of parts were made in the shop of S. Hawkridge, philosophical-instrument maker at the Stevens Institute.

*Cross-Int.* 47. Mr. Irwin is a gentleman who is in litigation with the Bell Telephone Company, and on whose behalf you have testified in that litigation as an expert a few weeks ago; is it not so?

*Ans.* That is so.

*Cross-Int.* 48. Do you consider that the cubical block instrument produced by you is made in exact accordance with the description in the Frankfort "Journal," referred to by you in your seventh answer?

*Ans.* Such is my belief.

*Cross-Int.* 49. And I suppose you have testified in that belief?

*Ans.* I have.

*Cross-Int.* 50. I understand, from your testimony, that a microphone transmitter, using that phrase in the sense in which you have defined it, will not transmit articulate speech if it habitually breaks

the contact between the electrodes at each vibration of the diaphragm; am I correct in that?

*Ans.* You are correct.

*Cross-Int.* 51. When you have referred to the transmission of articulate speech by the instrument which you have called a Reis transmitter, I suppose that you have meant to limit yourself to that operation of the instrument wherein the electrodes vary the contact pressure but habitually preserve the contact unbroken, do you?

*Ans.* I do.

*Cross-Int.* 52. In your testimony you have spoken of the instrument known as the Blake transmitter; is it an instrument which is extensively used in the community for the electrical tranmission of speech?

*Ans.* It is, very extensively.

*Cross-Int.* 53. How long have you known of its use?

*Ans.* Since it was first exhibited in use at the American Institute Fair, which I think was in the latter part of 1878.

*Cross-Int.* 54. I suppose you have read the other description of the Reis telephone which is given in the book of Pisco, referred to in your seventh answer, in addition to the one there referred to, haven't you?

*Ans.* I don't think I noticed the one on page 241.

*Cross-Int.* 55. I call your attention to the passages on 241 and 242 of said book, of which I hand you translation, and which purports to be a description by Reis himself of the construction and operation of the instrument as made for him by the mechanician Albert, Frankfort-on-the-Main, and ask you if you find anything in that which leads you to modify any of the views you have expressed?

*Ans.* I do not think that it would modify the views I have stated; because, in the first place, this description shows clearly that when at rest there was a closed circuit through the instrument, and under these conditions my experiments teach me that it will transmit articulate speech when spoken to in a natural manner. In order that this articulation should be heard, however, the ear must be brought in close contact with the receiver, even when this is of the best form; so that the experiment would be inapplicable for class

illustration, or for any of the purposes for which this instrument would naturally be sought after. It would therefore not be a circumstance which one would judiciously mention in a circular or advertisement, such as I understand this to have been. In fact I have a perfectly parallel illustration in my own experience. At the time I made the experiments which I before referred to with the singing telephone, in 1878, I had charge or superintendence of the instrument-maker's shop in the Stevens Institute, and caused to be printed a price list or catalogue, in which this apparatus occupied a conspicuous place. But though I knew perfectly well that articulate speech could be conveyed with that apparatus, I said nothing about it, as that was entirely foreign to the object of the apparatus, and would have only occasioned trouble through the probable failures to obtain such a result in the hands of inexperienced people.

*Cross-Int.* 56. I call your attention to an article by M. St. Edrue, published in *Cosmos* for March, 1864, and to a description of the Reis telephone, as made by Koenig, found in his catalogue for 1865; also to an article in *Dingler's Polytechnic Journal*, Vol. CLXVIII., page 185, published in 1863; also to the remarks of Prof. Clifton, delivered at the meeting of the Physical and Mathematical Section of the Literary and Philosophical Society of Manchester, England, Nov. 10, 1864, and reported in the Journal of that society; to an account of Bourseul's apparatus in Du Moncel's "Applications de l'Electricité," Vol. II., page 225, published in Paris in 1854; and to a paper by Du Moncel, published in *Comptes Rendus*, Paris, Nov. 27, 1877; and to a book called "Electricity," by R. M. Ferguson, published in London and Edinburgh in 1867, at pages 257, 258; to Hassler's "Lehrbuch der Technischen Physik," a book published at Vienna in 1866, at page 648 of Vol. I.; to a description of Reis telephones in "The Telephone," a book by A. E. Dolbear, published in Boston in 1877; to Atkinson's translation of the book called "Ganot's Physics," eighth edition, published in New York in 1877, page 757; and to the ninth edition of the same, published in New York in 1879, page 773; and to translations of all of said articles which are in foreign languages: and I ask you whether anything in those articles leads you to modify the views you have expressed in your deposition.

[*Complainants put in evidence the articles and translations referred to in the preceding two questions.*

*Objected to as immaterial and incompetent, and as not being proof of any alleged facts therein contained or set forth.*]

*Ans.* The opinions which I have expressed in reference to the Reis telephone have not been founded on any published authority or statement of experiments, beyond the descriptions of the structure and general mode of operation of the apparatus. I have founded no conclusion on the experiments of others, and therefore any negative results of such experiments ought not to modify conclusions which are founded on my own positive observations. Making, or taking as made, these instruments in precise accordance with the published description, and using them in a perfectly natural and ordinary manner, I have found them to transmit articulate sounds telephonically, and have therefore concluded that when these instruments were properly constructed they must have always possessed the capacity of thus transmitting articulate sounds when so used. The fact that a great number of persons had used these instruments without obtaining this result would of course be strange, if it were not explained by the fact that they were generally if not universally expecting something else from it, and using it in a way which would naturally exclude this operation, — which, as I have said, requires a gentle, not violent application of sound, and the employment of a sensitive receiver brought in close contact with the ear.

*Cross-Int.* 57. Look at the paper now shown you, and state whether your name thereon is your own signature.

*Ans.* It is.

[*Copy of paper put in evidence.*

*Objected to by defendants' counsel as irrelevant.*]

*Cross-Int.* 58. Did you attend a lecture and exhibition by Prof. Bell of his telephone, at the St. Denis Hotel, in New York, on or about May 11, 1877, and did you attend his lecture at Chickering Hall, at which he gave an exhibition and explanation of the electrical transmission of speech by his telephone?

*Ans.* I attended the lecture at Chickering Hall, but was not present at the previous exhibition.

*Cross-Int.* 59. Did you give a lecture on the electric speaking telephone at Hoboken, in June, 1877?

*Ans.* I did.

*Cross-Int.* 60. Did you at that lecture state to the audience that conversation could be carried on by means of the Reis transmitter, as made by Reis?

*Ans.* I did not.

[*Complainants' counsel put in evidence copies of the paper shown to the witness.*

*Objected to by defendants' counsel as incompetent, as not proved, and not rendered in any way material, relevant or admissible.*]

*Cross-Int.* 61. Does the apparatus shown in Edison's patent, 141,777, show any means by which, in the operation there exhibited, the operator at the transmitting station can control the extent of the motion of the armature of the receiving instrument at the receiving station?

*Ans.* It does not.

[*Adjourned.*]

*Direct Examination resumed.*

APRIL 28, 1881.

*Int.* 62. Referring to Cross-Int. 50, and answer, in which you state that a microphone transmitter will not transmit articulate speech if it continually breaks the contact of the electrodes at each vibration of the diaphragm, I refer you to the following portion of the Legat article in relation to the operation of the Reis instruments: "This also explains why chords and melodies were transmitted with marvellous accuracy in the practical experiments hitherto made, while single words in reading, speaking, etc., were less distinctly recognizable, although even in these the inflections of the voice, as in interrogation, exclamation, calling, etc., were clearly reproduced"; and I ask you whether, when the instruments described in the Legat article were operating to transmit words as described in said article, the transmitting instrument could have been breaking contact between the electrodes at each vibration of the diaphragm.

*Ans.* Assuredly not; indeed, I am convinced from this descrip-

tion that the apparatus must have been working exactly as it did with me when I obtained the transmission of articulate speech with it. In that case a rupture of contact, when it did occur from too loud speaking or an intentional movement of the lever, produced a violent rattling noise utterly inconsistent with the transmission of words.

*Int.* 63 In connection with Cross-Int. 57, a paper was shown you and put in evidence: will you state what that paper is, and whether you still entertain the opinions therein expressed?

*Ans.* The paper in question is a letter of invitation to Mr. Bell, which was sent to me with others for signature, and which expresses high appreciation of Mr. Bell's discovery of the telephone, as exhibited at the Centennial, and a desire that he would deliver a lecture on the subject in New York.

The opinion therein expressed as to the admirable character of Mr. Bell's invention I still entertain, and have acquired an even higher appreciation of his ability as a scientific investigator than I had at that time. But I think that this is entirely consistent with my opinion recently expressed in the present case, that Mr. Bell's patent, 174,465, does not contain the invention of the speaking telephone or apparatus competent to transmit articulate speech telephonically, or prevent me from recognizing the fact that the Reis telephone, as described in the publications which have been referred to, was capable of transmitting articulate speech telephonically. The entire absence of any reference to articulation, or to the transmission of words, in the patent 174,465, renders it, to my mind, impossible to suppose that the writer knew that such an effect could be produced by the apparatus, unless we suppose that, knowing it, he desired to conceal it in his description, which, as I understand, would be equally fatal to any claim founded upon such description. The fact that I find in my own experiments that the Reis instruments will transmit articulate speech also renders it impossible for me, with every possible regard for Mr. Bell, and respect for his genius, to doubt that they did so transmit articulate speech in the year 1862, when I read a statement to that effect such as that in the Legat article published at that time.

*Int.* 64. You have referred to several instruments of the defendants: please produce the instruments you have alluded to.

*Ans.* I do so.

[*Said instruments are marked "Defendants' Exhibit Transmitter" and "Defendants' Exhibit Receiver."*]

*Int.* 65. Please produce the translations of the three articles relating to the Reis receiver which you referred to in this evidence.

*Ans.* I do so.

[*Translations offered in evidence, and marked respectively "Defendants' Exhibit Translation Reis Article," "Defendants' Exhibit Translation Reis-Legat Article," and "Defendants' Exhibit Translation Reis-Pisco Article."*]

*Int.* 66. You said in answer to Int. 23, that you used the Reis instruments in connection with a form of receiver described in a patent of A. K. Eaton, No. 237,838: please state whether the instrument described in said patent operates at all upon the principle of a magneto telephone, such as shown in Bell's patent, No. 174,465, and whether in the instrument used by you the sound plate was in direct and solid contact with the end of the central rod or bar?

[*Objected to for the reason that the question does not relate to any matter or issue raised in the case, or opened on cross-examination.*]

*Ans.* This instrument does not act upon the principle of the magneto receiver shown in the Bell patent, but on the principle first developed by Mr. Page, and afterwards used by Reis in that form of his receiver described in the work by Pisco, already quoted, either alone or as modified by the influence of attraction between adjacent spirals of iron wire when magnetized, which, as far as I know, has not heretofore been used in any telephone receiver. The sound plate was in direct contact with the end of the bar, as I know by pressing upon it, and also from the fact that being of brass, no effect would have been produced upon it by the magnetic core, except through the medium of a mechanical contact.

[*Complainants object to the answer for the same reason as to the question, and therefore decline to cross-examine thereon.*]

HENRY MORTON.

Attest: JOSEPH GUTMAN, Jr., *Examiner.*

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NEW YORK, May 4, 1881.

*Present: Counsel for defendants.*

The defendants' counsel introduces in evidence the Letters Patent granted to the Eaton Telephone Company, as assignee of A. K. Eaton, dated Feb. 15, 1881, No. 237,838, and it is marked "Defendants' Exhibit Eaton Patent."

Attest: JOSEPH GUTMAN, Jr., *Examiner.*

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## DEPOSITION OF WILLIAM E. GEYER.

*Direct Examination by* FREDERIC H. BETTS, Esq., *of Counsel for Defendants.*

NEW YORK, May 4, 1881.

*Int.* 1. What is your name, age, residence, and occupation?

*Ans.* My name is William E. Geyer; my age is thirty-two years; my residence is at Hoboken, N. J.; and my occupation a chemist connected with the Stevens Institute of Technology, Hoboken.

*Int.* 2. Are you familiar with the German and English languages?

*Ans.* I am.

*Int.* 3. And with the scientific terms in both of said languages?

*Ans.* In the department of chemistry and physics, I am.

*Int.* 4. Please examine the several publications which have been introduced in evidence, entitled "Jahres-Bericht des Physikali-schen-Vereins zu Frankfurt am Main," printed and published in 1862, at pages 57 to 64; "Zeitschrift des Deutsch-Oesterreichischen Telegraphen-Vereins," Vol. IX., printed and published in 1862, particularly at pages 125–130; and "Die Neueren Apparate der Akustik, von Dr. Prof. Fr. Jos. Pisco," printed and published in 1865, particularly at pages 96 to 103; and the papers purporting to be translations thereof, which have been produced by President Morton, and are marked respectively "Defendants' Exhibit Translation Reis Article," "Defendants' Exhibit Translation Reis-Legat Article," and "Defendants' Exhibit Translation Reis-Pisco Article," and state whether the said last-mentioned three exhibits are correct

and true and full translations from the said German texts, at the pages specified, into the English language.

*Ans.* They are.

WILLIAM E. GEYER.

Attest: JOSEPH GUTMAN, Jr., *Examiner.*

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**EXHIBIT TRANSLATION REIS ARTICLE, J. G., JR., EX'R.**

*Yearly Report of the Physical Society at Frankfort-a-M.*, 1860–1, *p.* 57, "*On telephony by means of the galvanic current, by Philipp Reis.*"

The extraordinary results in the field of telegraphy have probably often raised the question, If it might not be possible to transmit speech itself to a distance? Experiments made in this direction could not, however, produce any result at all satisfactory, because the vbrations of conducting media soon lose their intensities to such an extent that they are no longer appreciable by our senses.

A reproduction of sounds at certain distances by means of a galvanic current has probably been thought of, but the practical solution of this problem has certainly seemed the most doubtful to the very persons who, from their knowledge and appliances, were in the best condition to attack it. To a person having only a superficial knowledge of physics the problem presents far less difficulties, simply because the most of them are unperceived. About nine years ago I also (having an extraordinary enthusiasm for what was new, and an insufficient knowledge of physics) had the boldness to attempt the solution, but was soon forced to desist because the very first experiment convinced me of the impossibility of its solution.

Later, after further study and experience, I came to see that my first experiment had been a very rough and by no means conclusive one; I did not, however, follow up this subject seriously, because I did not feel myself equal to the difficulties in the way.

Youthful impressions, however, are strong, and therefore not easily effaced. I could never get rid of the thought of that first experiment and its occasion, notwithstanding all that reason says to the contrary, and thus half unwillingly this project of my youth was

reviewed in hours of leisure; the difficulties and the means for overcoming them were weighed; but for the present, at least, no experiment was made.

How indeed could a single instrument reproduce the combined effect of all the organs occupied in human speech? This was always the cardinal question: finally I got the notion of putting the question in another way, —

How does *our ear* appreciate the totality of vibration produced by the organs of speech all simultaneously active? Or more generally, —

How do we appreciate the vibrations of several simultaneously sounding bodies?

To answer this question, we must, in the first place, understand what must happen in order that we may perceive a single tone.

Without an ear, any tone is nothing else than a recurrent condensation and rarefaction of some body repeated at least seven or eight times in a second. If this occurs in the same medium in which we are, the membrane of the ear is at each condensation forced towards the middle ear, to be moved at the subsequent rarefaction in the opposite direction. These vibrations produce a synchronous raising and falling of the hammer upon the anvil (according to other authorities, an approach or receding of the ear-bone particles), and a similar number of tremors in the fluid of the cochlea, in which the filaments of the auditory nerve are distributed. The greater the condensation of the conducting medium at any given moment, the greater is the amplitude of vibration of the membrane and hammer, and consequently the more powerful the blow upon the anvil and the vibration of the nerves by means of the fluid.

The office of our organs of hearing is, therefore, to transmit with certainty up to the auditory nerve every condensation and rarefaction occurring in the surrounding medium. But the office of the auditory nerve is to bring to our consciousness the vibrations of matter which have occurred in a given time, both as regards number and amplitude. Here, for the first time, certain combinations receive a name; here, certain vibrations are sounds or noises.

What our auditory nerve perceives is, then, simply the action of a force coming within the range of consciousness, and this force can

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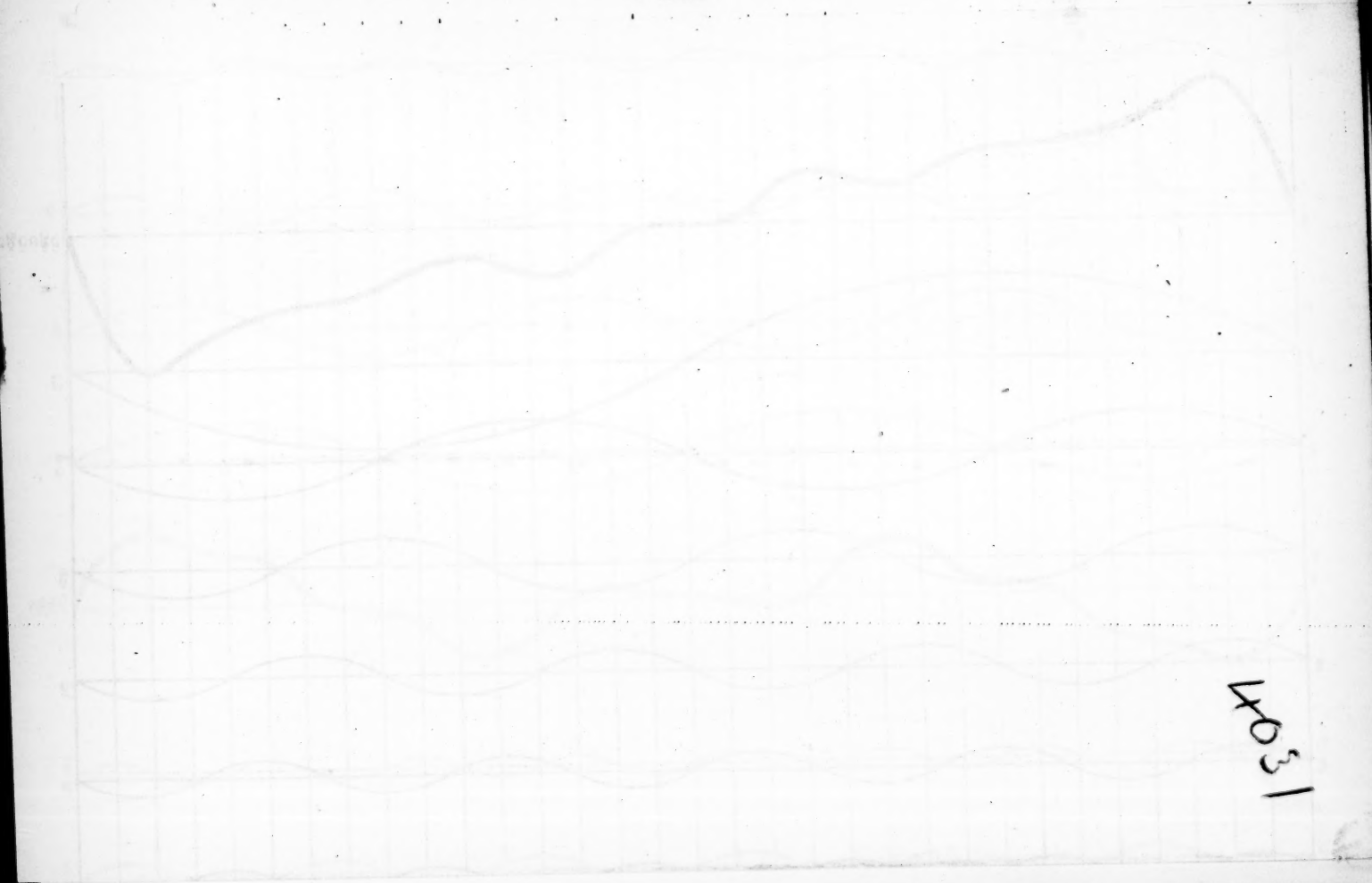
be represented both as to duration and magnitude by a curve, graphically.

Let *a b* represent any given time, and the curve above the line condensation (+), the curve below the line rarefaction (—), then any ordinate raised from the end of any abscissa will represent the degree of condensation, at the time represented by its base, in consequence of which the drum of the ear vibrates.

Our ear can under no circumstances appreciate more than can be represented by these curves, and this indeed is entirely sufficient to give us a clear perception of any sound or any combination of sounds.

If several sounds are produced at the same time, the conducting medium is subjected to the influence of several simultaneous forces, and the two following laws will hold good: If the forces act in the same direction, the amplitude is proportional to the sum of the forces; if the forces act in opposite directions, the amplitudes are proportional to the differences of the opposing forces.

If, for example, in the case of three sounds, we draw the curve of condensation of each separately by a summation of the ordinates of corresponding abscissas, we can determine new ordinates and develop a new curve, which might be called the combination curve. This represents exactly what our ear perceives of the three simultaneous sounds. The fact that the musician can distinguish the three sounds need not surprise us any more than the fact that any one acquainted with the theory of colors can in green discover blue and yellow; but the combination curves in Plate I. show that this difficulty is a slight one, for in these curves all the relations of the components successively recur. In the case of chords of more than three notes the relations are not so readily seen from the drawing, Plate II., for example. In the case of such chords, however, the skilled musician also finds difficulty in recognizing the separate notes.



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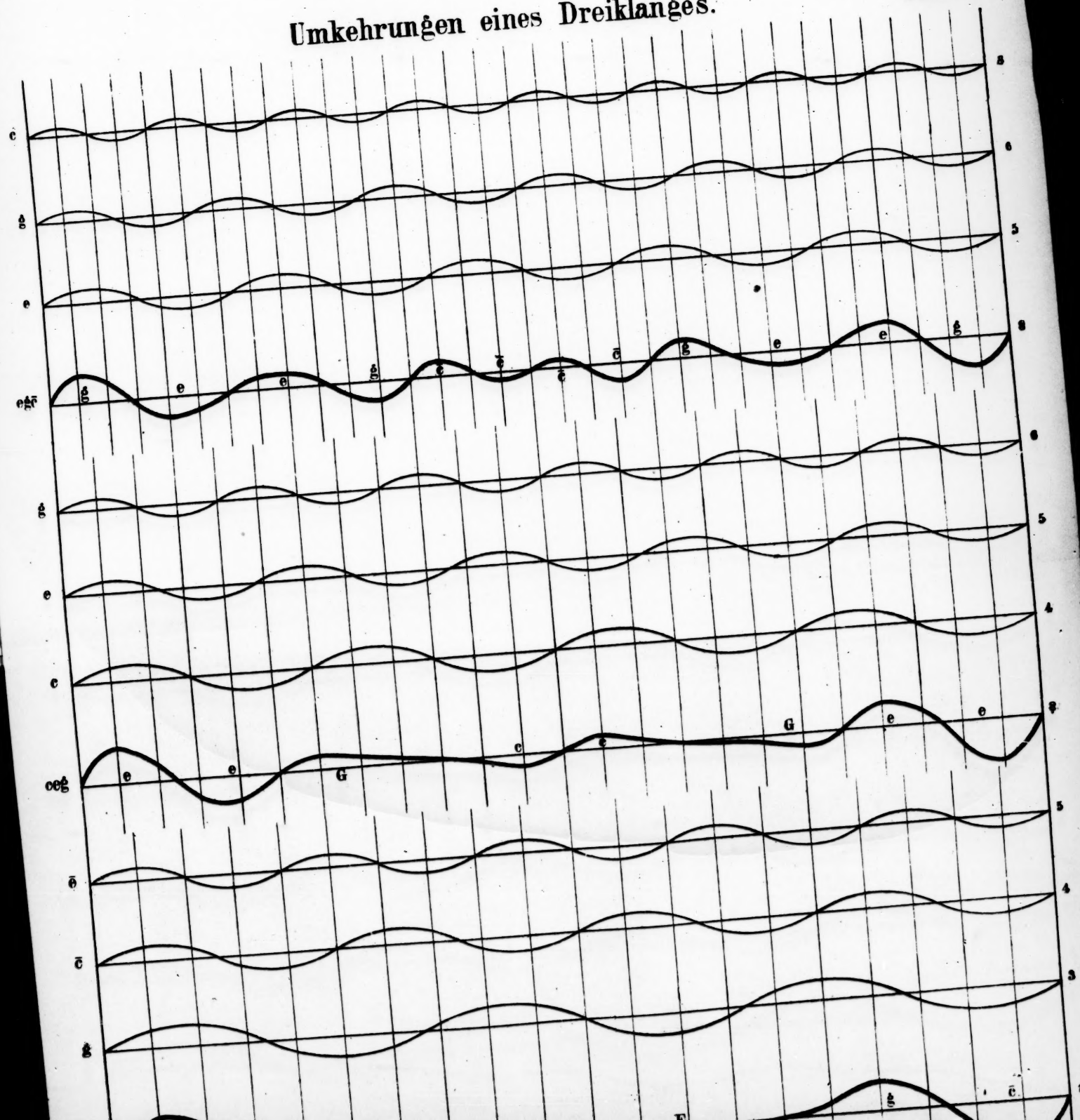
Tafel I.

# Umkehrungen eines Dreiklanges.



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Tafel II.

# C dur.

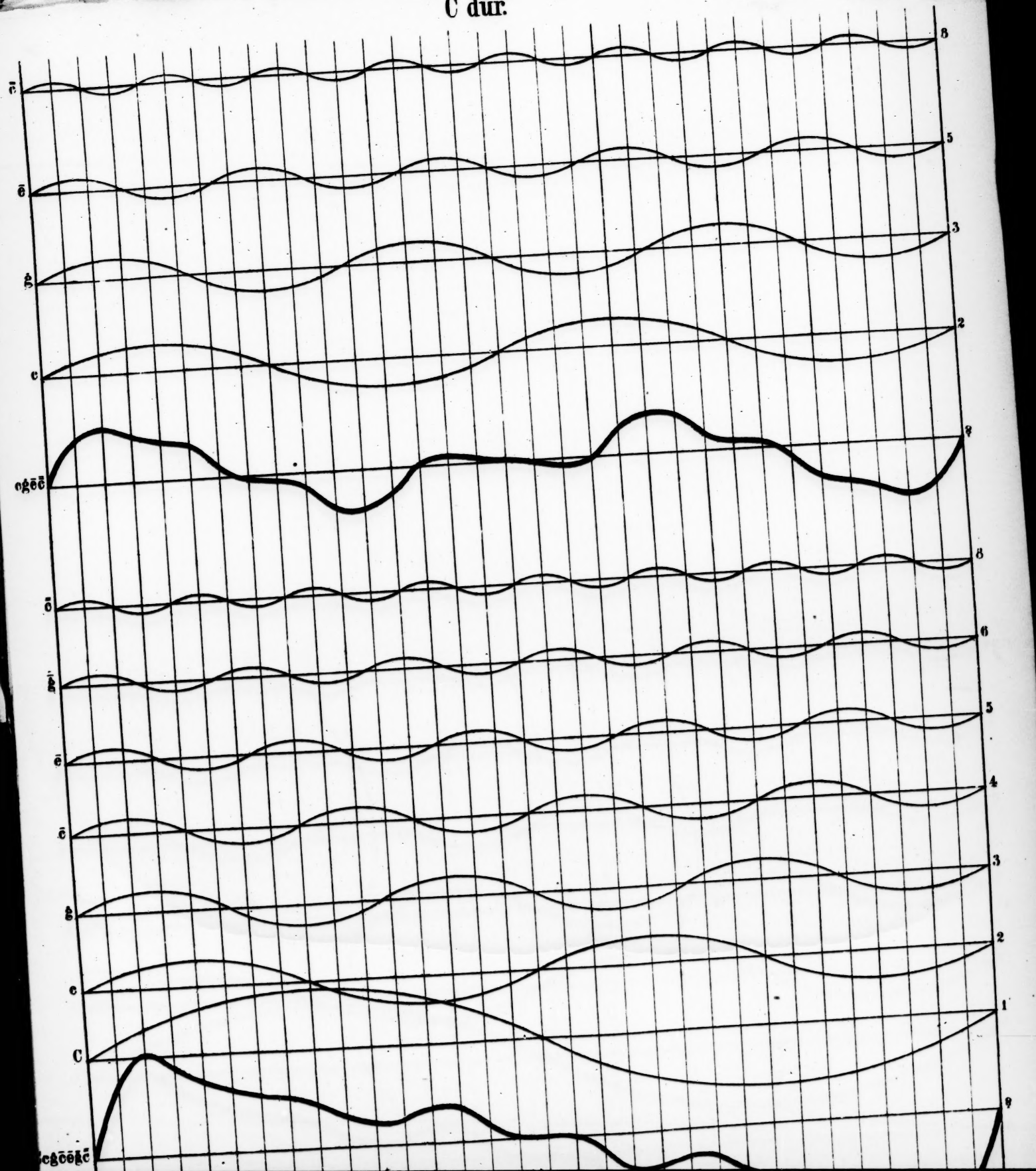


Plate III. illustrates discord. Why discords impress us unpleasantly I will leave my readers to judge at this time, though I may perhaps return to the subject subsequently in another paper.

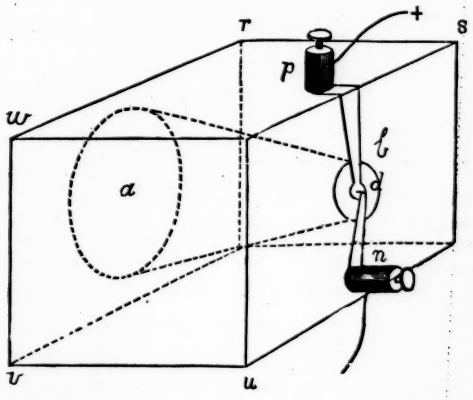
From the preceeding it follows: —

*First.* Every sound and every combination of sounds, on striking our ear, causes vibrations of the drum of the ear that may be represented by a curve.

*Second.* The course of these vibrations simply gives us a conception (appreciation) of the sound, and every alteration changes the conception (appreciation).

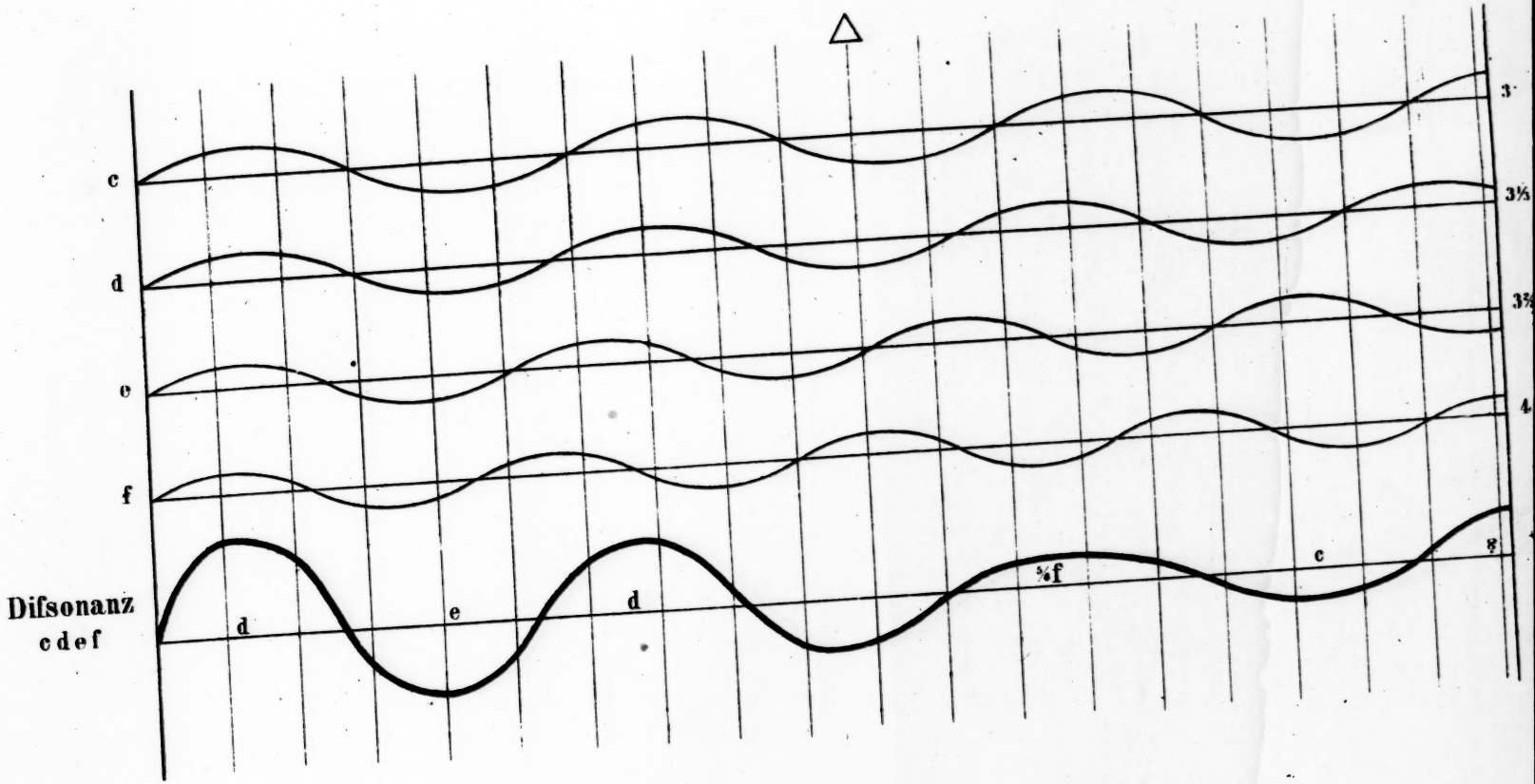
As soon then as it is possible to produce, anywhere and in any manner, vibrations whose curves shall be the same as those of any sounds or combination of sounds, we shall receive the same impression as that sound or combination of sounds would have produced.

With the above principles as a foundation, I have succeeded in constructing an apparatus with which I am enabled to reproduce the sounds of various instruments, and even to a certain extent the human voice. It is very simple, and by means of the figure will be easily understood from the following explanation.




In the cubical block of wood *r s t u v w x* there is a conical perforation *a*, closed at one end by a membrane *b* (pig's intestine), upon the middle of which there is cemented a conducting strip of platinum; this is connected with the binding screw *p*. From the binding screw *n*, another thin strip of metal extends until over the

Tafel III.



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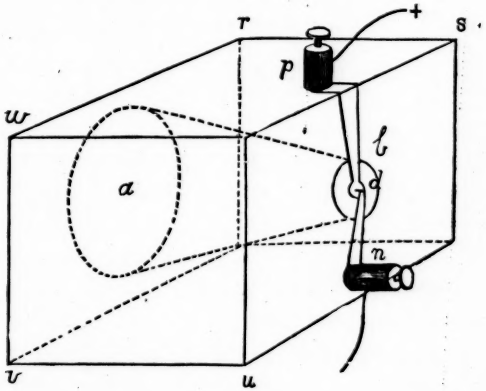


In the cubical block of wood *r s t u v w x* there is a conical perforation *a*, closed at one end by a membrane *b* (pig's intestine), upon the middle of which there is cemented a conducting strip of platinum; this is connected with the binding screw *p*. From the binding screw *n*, another thin strip of metal extends until over the

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middle of the membrane, and ends here in a platinum wire placed at right angles to its length and surface.

From the binding screw *p*, a conducting wire runs through the battery to the distant station, being connected with a coil of silk-covered copper wire, and this again is connected with a conductor leading back to the binding screw *n*.

The coil at the distant station is about six inches long, is composed of six layers of fine wire, and, as a core in its centre, has a knitting-needle which projects about two inches at both ends. By means of the projecting ends, the coil rests upon two bridges of a resonant case. (All this part can of course be replaced by any other apparatus by means of which the well-known "galvanic sound" can be produced.)

If now sounds or sound combinations are produced in the neighborhood of the block, so that sufficiently powerful waves reach the opening *a*, then these sounds cause the membrane *b* to vibrate. At the first condensation the hammer-like wire *d* is pushed back; at the rarefaction it cannot follow the retreating membrane, and the current traversing the strip is broken, until the membrane forced by a new condensation again presses the strip (proceeding from *p*) against *d*. In this way each sound wave causes a breaking and closing of the circuit.

At each closing of the circuit the atoms of the iron wire in the distant spiral are moved away from each other (Pouillet Müller, page 304, Vol. II., fifth edition); on breaking the circuit these atoms seek to regain their position of equilibrium. When this happens, in consequence of the reciprocal actions of elasticity and inertia a number of vibrations are produced, and they give the longitudinal sound of the rod (see as above). This is the case if the breakings and closings of the circuit occur with comparative slowness. If they occur more rapidly than the oscillations of the iron core, due to its elasticity, the atoms cannot complete their circuits. The paths described become shorter in proportion as the interruptions are more frequent, but then are just as numerous as these.

The iron wire no longer gives its longitudinal sound, but a sound whose pitch corresponds to the number of interruptions (in a given time); this is equivalent to saying *the wire reproduces the sound*

*conveyed to the interrupter.* The intensity also of this sound is proportional to that of the original one, for in proportion as this is more intense the motions of the membrane are greater; the motions of the hammer also, and finally the time during which the circuit is broken, is greater, and consequently, to a certain extent, the motions of the atoms in the reproducing wire are greater, we perceiving them as greater vibrations, in just the same way as we would have perceived the original sound wave.

As the length of the conducting wire can undoubtedly be made as great as in direct telegraphy, I have called my instrument "telephone."

Now, in reference to the capabilities of the telephone, it may be stated that was I enabled to render audible to the members of a large assembly (The Physical Society at Frankford-a.-M.) melodies which were sung not very loud into the apparatus in another house three hundred feet away, with closed doors.

Other experiments showed that the sounding wire was capable of reproducing complete chords of three notes of a piano, upon which the telephone was placed, and that it reproduces equally well the sound of other instruments: accordion, clarinet, horn, organ pipes, etc., provided that the sounds are within the compass F —f.

Of course, in all experiments, sufficient precautions were taken to insure that there was no direct conduction of sound. This is very easily done by making a momentary short circuit immediately in front of the coil, by which means its action is temporarily interrupted.

Hitherto it has not been possible to reproduce human speech with a distinctness sufficient for every one. The consonants are for the most part reproduced pretty distinctly, but the vowels as yet not in an equal degree. The cause of this, I will attempt to explain.

According to the experiments of Willis, Helmholtz, and others, vowel sounds can be produced artificially, if the vibrations of one body are from time to time augmented by those of another, somewhat as follows: —

An elastic wheel is set in vibration by the blow of a tooth on a toothed wheel; the first vibration is the greatest, and each subsequent one is smaller than the preceding.

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If to vibrations of this kind (the spring not coming to rest in the mean time) the blow of a new tooth is added, the following vibration will be again a maximum, and so on.

The pitch of a sound produced in this way depends upon the number of vibrations in a given time, but the character of the sound upon the number of intensifications in the same time. Two vowels having the same pitch would differ in about the way represented by the curves (Figs. 1, 2), while the same sound without any vowel character would be represented by the curve (Fig. 3).

*Fig.* 1.

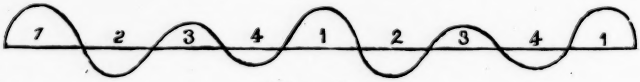


*Fig.* 2.

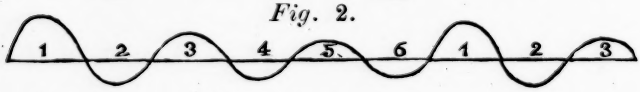


*Fig.* 3.

Our organs of speech probably produce the vowels in the same manner, through the combined action of the upper and lower vocal chords, or of these latter and the cavity of the mouth.

My apparatus reproduces the number of vibrations, but with an intensity much less than that of the original ones; but still, as I have reason to believe, to a certain degree proportional among themselves. But in the case of these generally small vibrations, the difference between large and small vibrations is more difficult to perceive than in the case of the original waves, and the vowel is therefore more or less indistinct.

Whether or not my views as to the curves corresponding to sound combinations are correct could perhaps be decided by means of the new phonautograph of Duhamel ("Vierordt Physiology," page 254).

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It may be that for the practical application of the telephone much remains to be done; for Physics it has already sufficient interest, from the fact that it *opens* a new field for research.

FRIEDRICHSDORF, NEAR FRANKFORT-A-M., December, 1861.

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## DEFENDANTS' EXHIBIT TRANSLATION REIS-PISCO ARTICLE, J. G., JR., EXAMINER.

*From Pisco's "Acoustic Apparatus,"* 1865.

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*a.* The "Telephone" of Reis (Fig. 60) is related to the Membrane Phonautograph. The round end *s* of a light strip of platinum *n s* is fastened upon the membrane *m m* with wax in such a way that the strip of platinum can make all the vibrations of the membrane with it. Very near to this end *s* of the strip of platinum *n s* is a platina point, fixed so that it is touched by the strip of platinum as this vibrates with the membrane. If we suppose the outer end *n* of the platina strip and the platina point to be connected with the poles of a battery, then a current is established or broken by the vibra-

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tions of the membrane, according to its phases. A magnetic piece of clock-work or an electro-magnetic telegraph introduced in this circuit would transmit to a distance indications of some one's speaking, but they would, self-evidently, not be able to make known what was spoken.

*b.* It is well known that an iron wire, surrounded by strong galvanic currents frequently broken, is made to sound forth tones which may be longitudinal or transverse, or both at the same time. Reis introduced such an iron wire lying in a multiplying coil at the second station C. This produced tones, if the membrane was caused to vibrate, by singing or talking into (*S*, Fig. 60) the hollow, cubical part A. In my experiments with the telephone, the rod never changed its pitch, even with the most different tones and sounds, and always produced only the rhythm of the words sung or spoken at *S* into the part A. The aria of the song sung into the instrument could generally be recognized from the rhythm. The experiments, with special reference to this, are recited in ¶ 53. But this much

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is evident already, that time must yet elapse before the simultaneous concerts and singing productions so ardently hoped for by the newspapers. The apparatus of Reis is indeed a "Telephone," but not a "Phonic Telegraph." The only means of transmitting song and speech, and this only for moderate distances, is the old well-known speaking tube. But the experiment of Reis can always be classed with the most beautiful and interesting of school experiments; and as the means for producing it are simple, the apparatus of Reis will surely soon find its way even into moderately endowed institutions. That the sounding of the wire in the telephone is not due to acoustic transmission can be shown by cutting the coil out of the circuit; the sounding ceases at once.

1. Reis's phonautograph was originally made of a wooden cube with a conical cavity. The smaller opening was covered with the membrane. A knitting needle was used as the sounding wire, which projected about 2″ out of each side of the multiplying coil, and rested upon two bridges of a resonance box. The surrounding coil

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consisted of six layers of fine wire. Fig. 60 shows the telephone as it is at present manufactured, according to the inventor's directions, by artisan Albert, in Frankfort, and artisan Uaeck, in Vienna.

2. Even though the telephone cannot be used to reproduce a concert, this can be accomplished for moderate distances by the resonance of solid bodies, in narrow limits, to be sure. Pepper, director of the Polytechnic Institute, formed at London for amusing sciences, gave such a concert (1855) with Wheatstone's method. Four of Erard's harps stood upon the stage. Each had a short 2 cm. thick staff of pine at its resonance board. By turning the harps on their axes this staff came to touch an entirely similar one which went into a deep cellar, and there was in contact respectively with the sounding board of a piano, a violonceilo, of a violin, and the mouth piece of a clarinet. As long as the resonance staffs touched, the concert was heard distinctly; but as soon as one or all the harps came out of contact with the sound-conducting staff, the music ceased. The character of the instruments played was, as a whole, preserved, only the violoncello tones being somewhat raspy.

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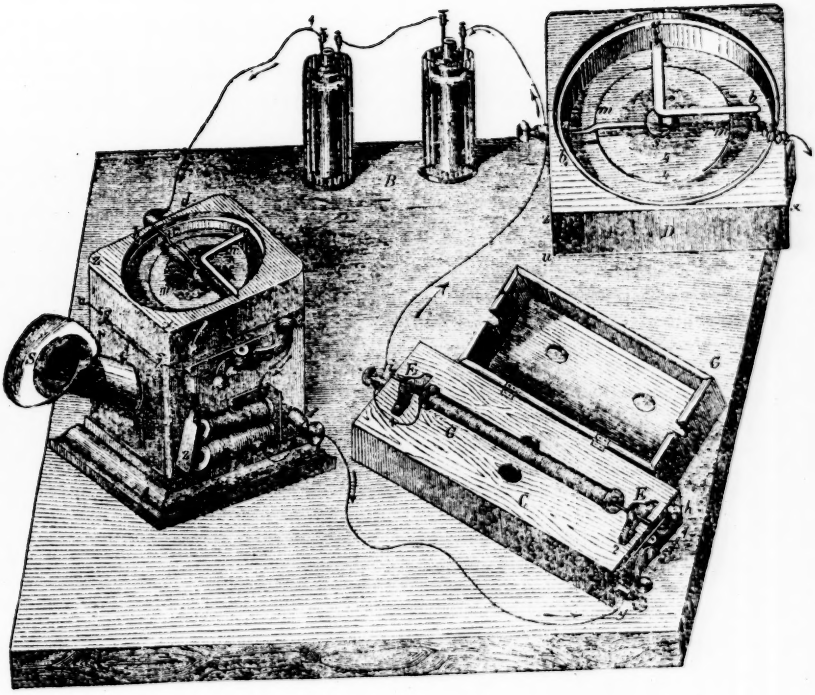

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52. *Particulars regarding the Telephone.*

*a.* It consists substantially of

1. The transmitter A.
2. The receiver C.
3. The battery B, and finally of
4. The conducting wires.

*b.* The transmitter A is essentially a parallel epipedic body of wood. Its upper part *u x* is cut out of a piece of square section, the side *z x* measuring 9 cm., its hight *u x* 2.8 cm.

This part can be moved from the lower box by means of hinges A A. If we turn back the cover *x u*, we will notice a small circle cut out in it 3.9 cm. in diameter. A brass ring, with a margin 8 mm. broad, fits into this hole, which margin has a flange along its side. The membrane *m m* is stretched over the ring by means of silk thread running along its side. This circular membrane is surrounded by a wider circular hollow *b b'* = 8.5 cm. A shovel-shaped strip of platinum *n s* is in connection with the binding post *d*, and is situated with the circular part *s* in the centre of the membrane.

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The platina is fastened to the membrane by sticking wax, and is thus compelled to vibrate with the membrane. The current is conducted from the centre of the membrane by means of the brass angle *a s b* (D, Fig. 60). This rests in *s* by means of a platina or steel point upon the conducting strip of platina *n s*, dips with a platina or steel point at *b* into a cup of mercury, which has been made in the screw by which the current is led on. The point *a* serves only as a support for the angle *a s b*, which was supported like a tripod, in order that the point of contact *s* might be as constant as possible. The angle *a s b* is simply slipped by means of the aperture at *a*, over a projecting piece, until it lies upon the broader, lower part underneath. From *b* the current goes by means of a coiled wire to the brass key *e* (A, Fig. 60), and from there in the direction indicated by the arrows.

The lower portion, A A, of the transmitter is made of wooden boards and forms a parallel epipedon whose hight is equal to 6.8 cm., and whose breadth is equal to 7.7 cm. For the reception of the tones the slanting attachment *s*, made of tin and with a funnel-shaped enlargement, is used. The longer side of this attachment

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measures 6.7 cm., the shorter 4.7 cm.; the vertical diameter of the enlargement measures 7.15 cm., horizontal diameter 7.5 cm., and finally the diameter of the narrower tube 8.9 cm. It is clear that in an emergency the strip of platina could be dispensed with *and a piece of thin sheet brass used instead*, and *iron points* used instead of steel or platina ones. The points of contact must then be kept polished brightly.

*c.* The receiver C is essentially a double resonance box, whose upper part, "the cover," is attached by two hinges and can be laid back. The length of this cover is 16.4 cm., its breadth 9.5 cm., and its height 3.2 cm. The length of the lower box is 22.9 cm., its

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breadth 9.6 cm., and its height 2.5 cm. The lower part of the resonance box carries two wooden bridges, 17.4 cm. distant from each other, and which serve to carry the sounding iron needle, the needle being 21.5 cm. long and 0.9 mm. thick. The length of the electro-magnetic coil encasing the middle is 15 cm. The wooden cover of both parts must be scraped as thin as possible, and the greatest width of the circular holes visible in the figure is 13 mm.

*a.* For battery a small four-cell Smee battery, or two large Bunsen batteries, can be successfully used. The line is made at least so long as to preclude one's hearing the original tones. For communication between the two stations the inventor has attached the electro magnetic telegraphic connections *e o g h*, which can be seen in the figure and is easy to comprehend. An understanding can be readily had as to corresponding signals, and the simplest thing is to accept those instituted by the inventor.

The receiver C produces the telegraphic signals through the sounding of E E when the key (*l*) is worked; while at the transmitter A the electro-magnet *v* indicates the signals by means of the spring armature *z*.

### 53. *Experiments with the Telephone.*

(*a.*) As soon as one brings his mouth to the telephone and sings, the membrane of the transmitter A goes into corresponding vibrations, and the iron rod E E at the second station begins to sound. As often as a *spark* at *s* at the first station appears, the rod

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is surely sounding at the other station. The same is the case when the peculiar whirring tone is heard due to the *impact* of the strip of platinum upon the point of the angle piece resting upon it. The fact of these sparks or the peculiar whirring at the transmitter C is thus evidence to an observer at the station A that the rod is sounding at C. Tones and melodies which were sung into the tube S, and



specially sounds the production of which caused sympathetic vibrations of the teeth and bones of the head (so-called humming tones), always effected a sounding of the rod or the needle E E, and this, as has been remarked (§ 51), *without a change of pitch*, simply with the reproduction of the rhythm of the respective song or words.

The pitch of the tone excited at C in the rod E E was $h'$ in the apparatus at my disposal, its strength not very considerable, and its sound whirring, similar to that of a weak reed-pipe (about that of a toy trumpet). The skin lying around the pericardium of smaller and even larger mammals (calves, etc.), answers best for the membrane. Gold-beater's skin reproduce only deeper tones. The cover of the resonance box proved to be useless with my apparatus, and the tone appeared to be somewhat stronger without the cover.

1. It must be carefully looked to in experimenting with the telephone that the end *s* of the strip of platina adheres to the membrane, and if need be, it must be pressed against the membrane. If it refuses to stick, some wax can be transferred on a heated knife-blade to the under side of the platina strip *n s*, which must at once be pressed against the membrane.

2. I take the liberty of recounting a few results here, out of a large series of experiments made by me.

*a*. A Caginard-Latour siren with an upright axis, blown from the deepest to the highest tone in front of the transmitter S, remained without result. It was only when the rotating plate was turned directly toward the sound-receiving funnel S, and brought very close to it, that twice at the medium pitch tones of the siren two short tones of the iron rod E E, about $h^1$ in pitch, were heard.

*b*. A tuning fork pitched at $a'$ produced no tone in the receiver C, either in the close proximity, or by being directly applied to the sound funnel S.

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*c.* A metal bell, which produces the tone $h^1$ or $d\,i\,s^2$, on having a strong bow drawn over it, had no effect upon the telephone, no matter how closely it was brought to or even applied to the sound

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tube S. When the tone $h^1$ had been very considerably increased by means of a resonance tube, the telephone responded shortly and weakly, and with $h^1$.

*d.* Wooden lip pipes inside of the scales belonging to $c^1$ and $c^2$, if applied with their pipes to the sound funnel S, and then blown, elicited nothing from the telephone; but they did act upon the telephone when the lower open end of the pipe was brought directly in front of or into the tube S at the transmitter A: this position may be called the "first." These pipes were effective upon the telephone also when their mouths (the excision) was applied to the transmitter S: this position may be called the "second." If in both the positions the pipes were removed only a few lines from the sound-receiver S, the membrane did not vibrate effectively, and ceased sooner in the first position than in the second; however, if pipes of various lengths (1 to even 8 feet) and various widths were applied to the transmitting tube, no matter what their material, and if the previous pipes were applied to these in the first or second position, the telephone produced the same result as under the immediate use of the short transmitting tube.

*e.* The previous pipes, if they were covered, caused (as could be foreseen) the telephone to sound either interruptedly or not at all, in the first position. In the second position they excited the telephone completely, and rarely interruptedly.

*f.* I had no pipes of the $c^3$ scale at my disposal. Tones out of that scale produced by blowing hard into the pipes I used, remained without effect, no matter in what position the pipe was put.

*g.* A reed pipe of the tone $d^1$ with a beating reed, only then acted upon the rod of the telephone when its open end was turned toward and brought near to the sound-receiving funnel S of the transmitter A. The strengthening of the tone by means of a sound trumpet caused a continuous tone.

The result was the same with a tongue pipe of the tone $c^1$ with

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full beat tongue, only that the telephone tone in this case was always intermittent.

*h.* The miniature — normal — diapason, a small reed pipe of the tone $a'$ (see Chap. VI.) introduced into the transmitter tube, so that its mouth lay at the funnel, excited a distinct tone in the telephone when strongly blown.

*i.* Marches, drummed at A with the key *ex*, were reproduced by the receiver C, and as usual in the tone $h^1$.

*k.* The singing of different melodies was always successful; the rhythm of speech was reproduced only with interruptions.

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*l.* Whistling into *S* remained without any result, and the tone became higher in pitch because the whistle becomes shorter. The tones produced by whistling $f^1$, $g^1$, $u^1$, $fis^1$, $c^1$, became respectively $fis^1$, $gis^1$, $b^1$, $g^1$, $cis^1$ and $d^1$ as soon as the mouth was brought directly in front of the sound receiver S. The same rise in pitch is brought about by whistling into a teacup, a hat, etc. Cutting off the current with the open palm raises the pitch in whistling, a fact to be plainly perceived when the hand is rapidly moved up and down.

*m.* As the audible rattling of the platina strip at the transmitter A is a sure indication that the wire rod E E in C is sounding, no telegraphic communication in reference to this is necessary between the stations (§ 52, *d*).

*b.* Comparing the results of experimenting with the telephone with those on the membrane phonautograph, it would at first seem as though the latter accomplished much too little in comparison with the former. This contradiction soon vanishes, however. The membrane phonautograph, too, gives as distinct writings of a melody within an octave, together with double tones and chords, and, according to Douders, much more even. In addition to this, the membrane in the telephone is caused to vibrate, not only by the vibrations of that tone by which it could, according to the laws of sympathetic vibrations in sound, be brought to vibrate, but it is also depressed and raised mechanically by the great condensations and rarefactions in the enclosed atmosphere, due to the original causative tones (singing, etc.). Every condensation presses the membrane outward,

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even if its lowest proper tones are much higher than the causative tone (tone *m n g*). Very strong and thick membranes might possibly resist this purely mechanical impulse, but they would not be sufficiently sensitive then for real sympathetic vibrations. The motion of the membrane in the telephone, then, is produced in many cases (for instance, in drumming with the key at the box, when the apparatus A stands upon the resonance cover of a piano, etc.) only in the same manner as in the membrane of König's pipe for showing the nodes of vibration (compare in a subsequent paragraph).

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In this, the indication of the rarefaction and condensation of the air in the tube outward does, likewise, not depend on the tension of the membrane.

Another proof is formed in pipes with thin walls. The latter allow tremors to be felt when touched with the hand, while the pipes are sounding; indeed, very thin walls lower the tone somewhat, and thus show that they are not capable of withstanding the pressure due to the condensation.

Sand sprinkled on such walls is thrown off at the nodal points. If accordingly thin strips of wood can imitate the vibrations of the air in the pipe in such a manner, although the proper tone of the pipe may be far distant from the causative tone, then this is all the more the case with a membrane. The experiments with the pipes adduced in the previous paragraph also speak for this, which experiments only then elicited a result in the telephone, when the open end of the mouths of the pipes were brought very close to the sound receiver; indeed, even the singing experiments confirm this view. Just these experiments show the telephone to be the weaker in comparison with the membrane phonautograph, since with the latter, when the membrane is tuned for a time, the script of the tone comes, no matter what position the source of the tone may be in as regards the sound-receiving side of the membrane phonautograph, if it is only brought near enough. And it would seem that less force were required to close the battery by means of the vibrating sheet of platina on the membrane, than for a motion of the little spring which removes soot from the writing cylinder. The results of the few experiments with the telephone seem furthermore to indicate, that

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for an easier production of tone scripts with the membrane phonautograph, it would be advantageous to manufacture the latter of smaller dimensions than hitherto. König is now busying himself, in point of fact, with new arrangements for the membrane phonautograph.

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König hopes for a better result in the written reproductions of simple melodies sung, if the wide orifice of the paraboloid in the membrane phonautograph is closed with a plate which contains a little opening for the mouth.

At all events, a renewed study of the laws of sympathetic vibrations of membranes will become necessary with reference to both apparatuses. Many think membranes must vibrate sympathetically at every tone, because all tones are heard by the agency of the membranes in the ear; in this matter it is very important to note that according to Prof. Mach, this might be effected by a peculiar mechanism of accommodation in the ear. This supposition of an accommodation in regard to the varying tensions of the membrane of the ear, has to me a degree of probability closely bordering upon certainty.

Ph. Reis showed his apparatus for the first time in October, 1861, to the Physical Society at Frankfort-a-M., in a very primitive state; in the form represented in Fig. 60 to the same society the 4th July, 1863. This time he experimented at a distance of 300 feet. Prof. Boettger exhibited the apparatus to the convention of naturalists at Stettin (1863) in the department of physics.

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**DEFENDANTS' EXHIBIT, TRANSLATION REIS-LEGAT ARTICLE, J. G., JR., EXAMINER.**

*Journal of the German-Austrian Telegraph Association, V. 9, p. 125, 1862, concerning the reproduction of sounds by means of galvanic electricity, by V. Legat, Royal Prussian Telegraph Inspector at Cassel, accompanied by copperplates VIII. and IX.*

It might not be uninteresting to make known, in wider circles, the following suggestions, communicated by Mr. Philip Reiss, during his time, to the Society of Physics, and to the meetings of the Free German Institute, at Frankfort on the Main, concerning the repro-

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duction of sounds by means of galvanic electricity, and, also, what has been hitherto accomplished towards the realization of this project, in order that the accumulated experiments may serve as a foundation to build upon, and that the capacity of the electric current, which by human ingenuity has already been made serviceable for correspondence, may be developed in this direction also.

In this essay we will not deal with the electric current as to its capacity for operating telegraphic apparatus of whatever construction for the reproduction of *visible* signs, but of the application of this current to the production of *audible* signs, of *sounds!*

The air waves, which by penetrating the ear excite in us the sensation of sound by primarily setting the membrane of the drum into vibratory motion, are, as is well known, transmitted to the interior parts of the ear and to the auditory nerves by means of a lever apparatus of wonderful delicacy, the auditory bones, hammer, anvil, stirrup; and the attempt to reproduce sounds therefore depends upon this, to actuate an artificial imitation of this lever apparatus by means of the vibrations of a membrane corresponding to the membrane of the ear drum and thereby to open and close an electric circuit, connected with a distant station by a metallic conductor.

Before describing the apparatus to be used, it would be proper to inquire how our ear apprehends the vibrations of any one particular sound, and the combined vibrations of all simultaneous sounds acting upon it, because thereby we may determine with certainty what will be the requirements of the receiving and delivering apparatus in the solution of the problem.

Examining first the processes which take place in order that the human ear may apprehend any simple sound, we find that each sound is the result of alternate expansions and condensations repeated within a fixed time. If this operation occurs in the same medium in which the ear is placed, then at each condensation the membrane is forced toward the cavity of the drum, and toward the opposite side at each expansion.

These vibrations impart corresponding movements to the auditory bones, and are thereby transmitted to the auditory nerves.

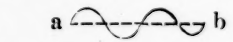
The greater the degree of condensation of the sound-imparting medium is at a given time, the greater will be the amplitude of

vibration of the membrane and auditory bones, and the consequent result; and in the opposite case, so much the weaker. Hence it is evidently the function of the auditory apparatus to impart with precision to the auditory nerves every condensation and expansion which occurs in the surrounding medium. On the other hand the function of transmitting to our consciousness the resulting vibrations occurring within a given time, according to number as well as intensity, devolves upon the auditory nerves.

It is here, in our consciousness, that a certain composition receives its name; it is here, in our consciousness, that the transmitted vibrations become "sounds."

Accordingly, that which has been imparted to the auditory nerves is the action of a force, communicated to our consciousness, and may therefore be made more easy of comprehension, as to its duration and strength, by graphical delineation.

For example, let the length of the line *a-b* represent a definite period of time, the curves above this line the condensations (+),




and the curves below this line the expansions (—); then an ordinate erected at the end of any abscissa will indicate the degree of condensation at the moment of time indicated by this abscissa, in consequence of which the membrane of the drum vibrates.

The ear is not capable of perceiving more than is represented in this way, or more than may be represented by similar curves; this is, however, sufficient to convey to our consciousness any simple sound or any required combinations of sounds. For if a number of sounds are generated simultaneously, then the sound-imparting medium is influenced by several forces, acting at the same time, which are subject to mechanical laws.

If all the forces act in the same direction, then the amount of motion is in proportion to the sum of all the forces; if on the other hand the forces act in opposing directions, then the amount of motion is in proportion to the difference between the opposing forces.

From these principles it follows that the curves representing the condensations of a number of simultaneously generated sounds may be combined in a single curve of condensation, which will indicate

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with precision the effect upon the ear of these simultaneously acting sounds.

The objection generally made to this proposition, that a musician, or any person, is able to distinguish the simple sounds out of which these composite curves are formed or arise, should not be allowed to militate against it; as it is also possible for some who are familiar with the study of colors to distinguish, in green, for example, the mixture of yellow and blue, in their varied shades, and the one phenomenon as well as the other is referable to the fact that each observer is very familiar with the factors of that product which has been conveyed to his consciousness.

By the explanations heretofore given, it is easy to construct the curves representing the condensations of various tones, chords, etc., and a few examples are given by way of illustration: —

Figure 1, plate VIII., represents a composite curve formed of three tones, in which all the proportions of the components reappear successively.

Figure 2 represents a similar curve formed of more than three tones; in this case, however, it is no longer possible to represent the proportions so clearly in the drawing, yet an experienced musician will be able to discern them even here, although in practice it might be difficult for him to recognize the simple tones in such a chord.

The advantage of representing the operation of sounds upon the human ear after this manner, is that it gives the clearest view possible of their origin; the representation here given also shows why a discord (dissonance), Fig. 3, must affect the ear disagreeably.

This apparent digression from the subject under consideration was necessary to demonstrate that as soon as we are able, in any place and in any manner, to reproduce vibrations of such curves and intensities as are equivalent to the curves and intensities of the vibrations of any particular sound, or of any particular combination of sounds, we will have the same impressions as were produced upon us by this original sound, or these original combinations of sounds.

The apparatus described hereafter offers the possibility of producing these vibrations in every manner desired, and by the use of galvanic electricity it is possible to evoke, at any distance, vibrations corresponding to those which have been so produced, and in

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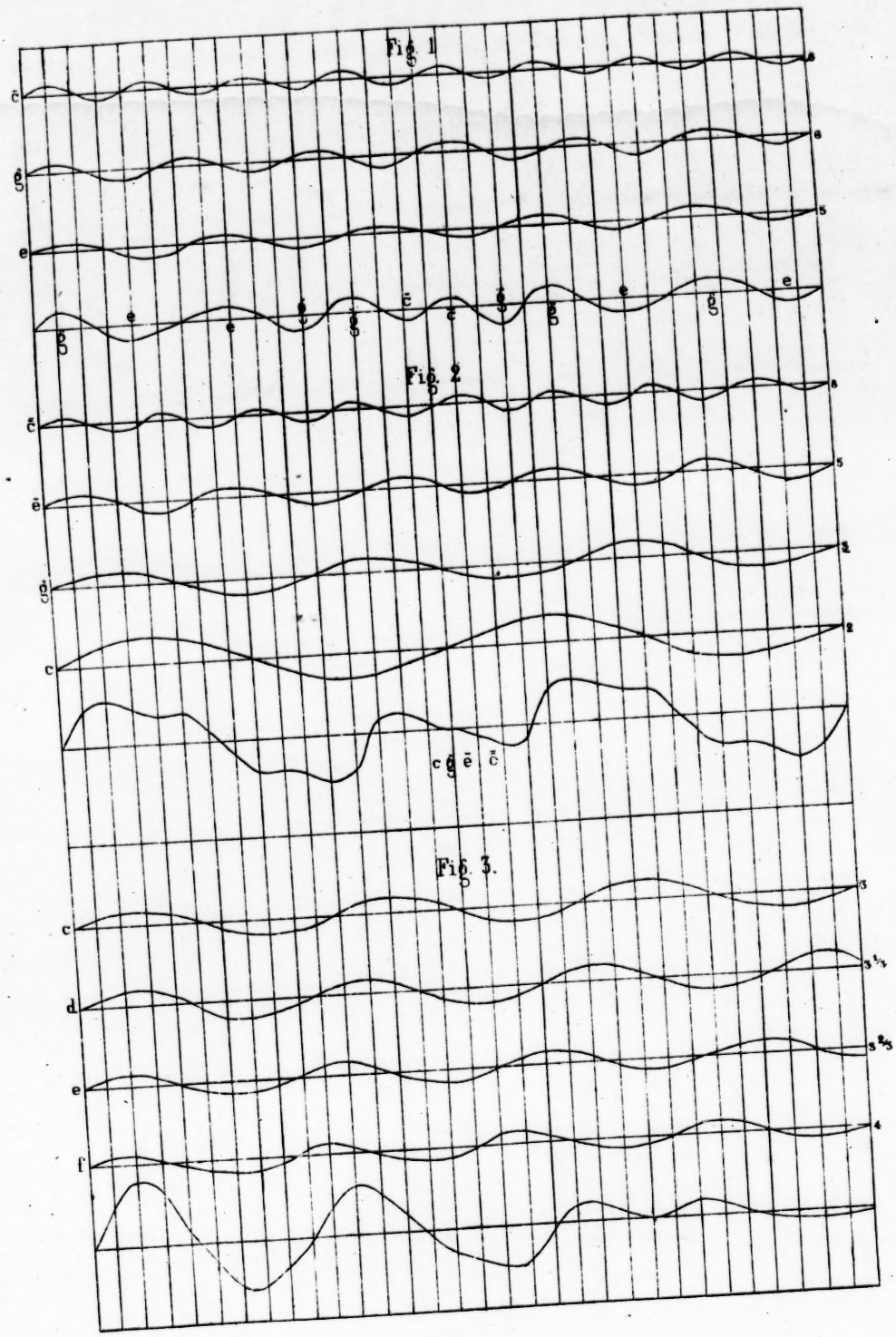
v. Legat, Reproduction von Tönen auf elektro galvanischem Wege

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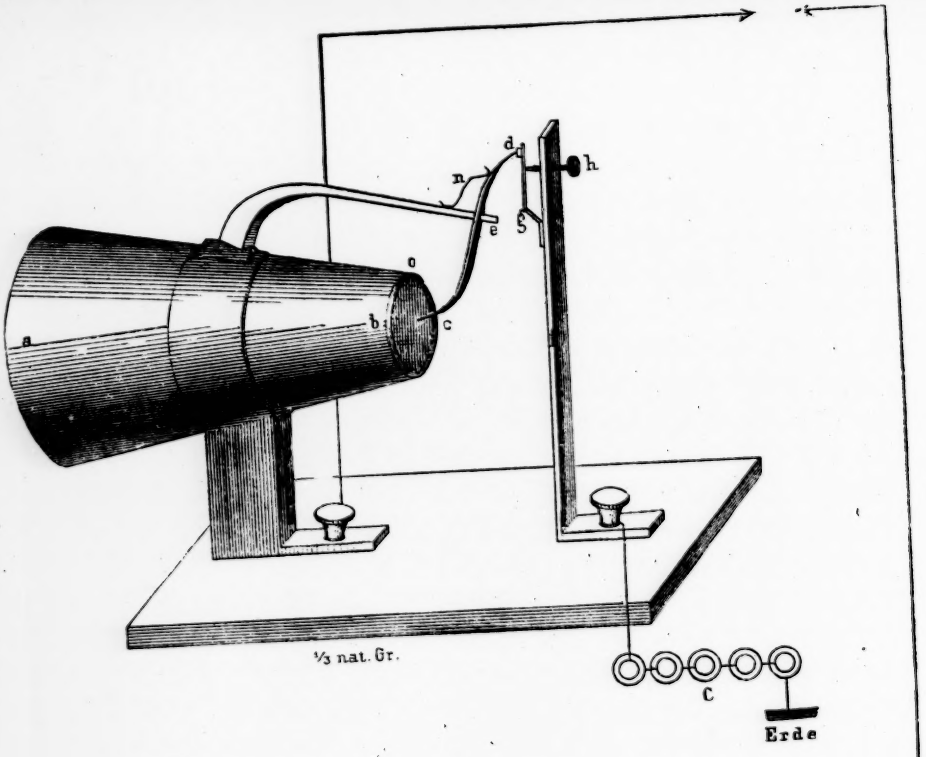


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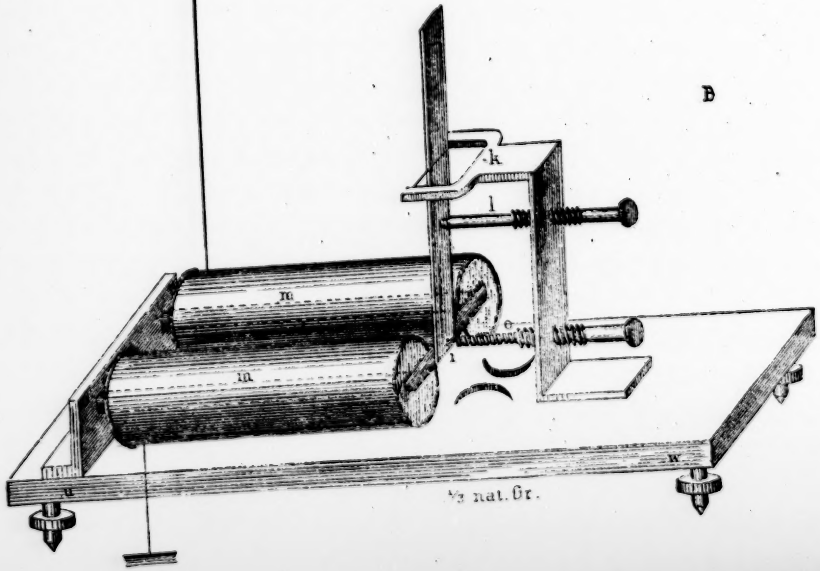

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this way to reproduce at any place the sounds which have been generated at another place.

A, of Fig. 4, of the accompanying plate IX., represents the sound transmitter, and B the sound receiver; these are placed at different stations. Let me premise, however, that for the sake of clearness, the combination of the pieces of apparatus for alternately transmitting and receiving, have *been omitted;* also, there has been left out of consideration, as this contrivance is not intended to present the completed structure, but only to make known to a wider circle the discoveries which have thus far been made, the possibility of extending the action of the apparatus, in practice, to a distance beyond the limit now reached by the direct action of the electric current, as these points are easily accomplished by mechanical devices, and have no special bearing upon the phenomena under consideration.

Let us now turn to the sound transmitter, Fig. 4 A. This on the one hand is connected by the metallic conductor with the sound receiver, Fig. 4 B; at a neighboring station on the other hand it is connected by means of the electric battery C with the earth, or with the metallic return conductor. The sound receiver, Fig. 4 A, consists of a conical tube *a b*, abont 15 centimetres in length, having a front opening of about 10 centimetres, and a rear opening of about 4 centimetres.

It appeared by practical experiments that the material of this tube was without influence upon the action of the apparatus; also that increased length did not induce greater precision. An enlargement of the diameter of the tube impairs the usefulness of the apparatus, and it is desirable that the inner surface of the tube be as smooth as possible. The smaller or rear end of the tube is closed by a collodion membrane *o*, and upon the centre of the circular surface of this membrane rests one end *c* of the lever *c d*, the supporting point *e* of which is sustained by a bracket, and is held in connection with the metallic conductor. The proper length of the respective arms *c e* and *e d* of this lever is regulated by the laws which govern the powers of levers. It is advisable to make the arm *c e* longer than the arm *e d*, in order that the least motion at *c* may operate with greatest effect at *d*. It is also desirable that the lever itself be made as

light as possible, that it may follow the movements of the membrane. Any inaccuracy in the operation of the lever *c d* in this respect will produce false tones at the receiving station. When in a state of rest the contact at *d g* is closed, and a delicate spring *n* maintains the lever in this position.

The second part of the apparatus, the standard *f*, consists of a metallic support, connected with one pole of the battery C, the other pole of which is connected to the earth, or to a metallic return wire leading to the other station.

Upon the standard *f* is arranged a spring *g*, with a contact point corresponding to the contact point *d* of the lever *c d*, the position of which is regulated by the screw *h*.

In order that any undulations of the atmosphere generated at the rear side of the membrane may not impair the operation of the apparatus by being imparted to the membrane, it is desirable to place a disk of about fifty centimetres in diameter at right angles to the longitudinal axis *a b*; this disk may be attached to the tube by a fastening surrounding the outer circumference of the tube.

The sound receiver, Fig. 4 B, consists of an electro-magnet *m m*, which rests upon a sounding board *n w*; its encircling wires are connected respectively with the metallic conductor and the earth or the metallic return conductor.

Facing the electro-magnets *m m* is an armature, to which is attached a light and broad lever *i*, which should be as long as possible.

The lever *i* with the armature is suspended from the standard *k* in the manner of a pendulum, its motion being regulated by means of the screw *l* and the spring *q*.

In order to increase the capacity of the apparatus, the tone receiver may be placed at one of the focal points of an elliptical chamber of suitable size, and the one listening to the reproduced sounds may place his ear at the other focal point of this chamber.

The operation of the apparatus described is as follows: —

When at rest the electric circuit is closed. When the air, which is in the tube *a b* of the apparatus, Fig. 4 A, is alternately condensed and rarefied, by speaking into it (or by singing or introducing the tones of an instrument), a movement of the membrane clos-

ing the smaller opening of the tube is produced, responsive to such condension or rarefaction. The lever *c d* follows the movements of the membrane, and opens and closes the electric circuit at *d g*, so that at each condensation of the air in the tube the circuit is opened, and at each rarefaction the circuit is closed.

In consequence of this operation, an alternate demagnetization and magnetization of the electro-magnet of the apparatus, Fig. 4 B, is produced, resulting from the condensations and rarefactions of the air in the tube *a b* of the apparatus Fig. 4 A, and thus vibrations corresponding to the vibrations of the membrane in the transmit ting apparatus are induced in the armature of the magnet. But the plate *i* attached to the armature communicates these corresponding vibrations of the armature to the air surrounding the apparatus Fig. 4 B, which accordingly transmits the vibrations so produced to the ear of the listener.

We are not here treating of the propagation of sounds by means of the electric current, but only of the transmission of generated sounds to another place, and showing that at the latter place like causes will produce like results. It must not be ignored, however, that while the apparatus described reproduces the exact number of the original vibrations, the reproduction of the vibrations in their intensity has not yet been achieved; and in order to perfect the apparatus, this remains to be accomplished.

In consequence of the imperfection of the apparatus at this time, the minor differences of the original vibration are distinguishable with more difficulty, — that is, the vowel sounds appear more or less indistinct,— inasmuch as each sound depends not merely upon the number of the vibrations of the medium, but also upon its condensation and rarefaction.

This also explains why chords and melodies were transmitted with marvellous accuracy in the practical experiments hitherto made, while single words in reading, speaking, etc., were less distinctly recognizable, although even in these the inflections of the voice, as in interrogation, exclamation, surprise, calling, etc., were clearly reproduced.

There is no doubt that the subject we have been considering, before it becomes practically valuable for use, will require con-

siderable improvement; it will especially be necessary to perfect the mechanism of the apparatus to be employed: but I am convinced, by repeated practical experiments, that it is of the greatest theoretic interest to pursue these investigations, and also that a development of practical value will not elude our intelligent century.

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NEW YORK, May 4, 1881.

The complainants object that certain passages in the Legat article are not correctly translated, and offer in evidence a translation of the part objected to, prepared or revised by F. L. Pope, Esq., formerly electrician of the Western Union Telegraph Company, and published in the periodical entitled "Journal of the Telegraph," for Dec. 1, 1877. Said passage is as follows: —

"It will be seen, therefore, that the result produced by this apparatus is not the veritable transmission of sound by means of the electric current, but is simply a reproduction of the tones at some other point, by setting in action at this point a similar cause, and thereby producing a similar effect. It must however be admitted that while the apparatus which has been described reproduces the original vibrations with perfect fidelity, so far as their number and interval is concerned, their intensity or amplitude cannot as yet be transmitted. The accomplishment of this latter result, therefore, must await the further development of the invention. It is in consequence of this defect in the apparatus that the more inconsiderable differences of the original vibrations are distinguished with great difficulty, — that is to say, the vowel sounds are heard with more or less indistinctness, for the reason that the character of each tone depends not merely upon the number of the sonorous vibrations, but upon their intensity or amplitude also. This also accounts for the observed fact that, while chords and melodies are transmitted and reproduced with a surprising degree of accuracy, single words, as pronounced in reading or speaking, were but indistinctly heard, although in this case also the inflections of the voice, interrogative, exclamatory, etc., could be distinguished without difficulty."

[*Defendants' counsel objects to said paper as not evidence, and because there is no proof of the correctness of the above translation.*]

Attest: JOSEPH GUTMAN, Jr., *Examiner*.

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# EVIDENCE FOR COMPLAINANTS IN REPLY.

TAKEN PURSUANT TO THE SIXTY-SEVENTH RULE OF THE SUPREME COURT OF THE UNITED STATES, IN EQUITY, AS AMENDED, BEFORE ME,

GEORGE H. EVANS, *Notary Public*,
*Special Examiner*.

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NEW YORK, May 10, 1881.

Present: JAMES J. STORROW, Esq., *Counsel for the Complainants;* F. H. BETTS, Esq., *Counsel for Defendant* SPENCER *in the Massachusetts suit, and for the Defendants in the New York suit.*

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1. The complainants put in evidence, under the stipulation heretofore made, all the depositions and evidence introduced by the complainants in reply, in the suit Bell Telephone Company *et al. v.* Peter O. Dowd, the said depositions and evidence to stand as evidence in this cause, with the same effect as if said depositions and evidence had been taken and sworn to in this cause.

2. The complainants desire to introduce as evidence in this cause the depositions of A. G. Bell and Thomas A. Watson, heretofore taken on behalf of A. G. Bell in the "Telephone Interferences A to L," and the defendants desire that the cross examination of said Bell in said interferences be also introduced; whereupon it is agreed that the copies of the said depositions of said Bell and said Watson, now produced, stand as evidence in this cause with the same effect as if duly taken on behalf of complainants and sworn to herein.

3. The complainants put in evidence the books and papers referred to in the following cross interrogatories and answers of Prof. Morton in this cause, viz., 54th, 55th, 56th, and answers and translations thereof, and it is agreed that the said articles were printed and published at the respective dates. Said articles are as follows: —

4. Article and description by Philip Reis on pages 241 and 242 of the book entitled "Die Neureren Apparate der Akustik von Dr. Fr. Jos. Pisco," published at Vienna, 1865, marked "No. 4, Reis Prospectus."

5. Article in "Dingler's Polytechnic Journal," Vol. CLXVIII., page 185, published in 1863, marked "No. 5, Dingler's Description of Reis."

6. Article by Mr. St. Edmé from the book called "Cosmos," Vol. XXIV., pages 349–352, published in Paris, 1864, marked "No. 6, Cosmos's Description of Reis."

7. Description of the Reis telephone as made by Koenig, found in "Koenig's Catalogue of Apparatus for 1865," published in Paris, 1865, and marked "No. 7, Koenig's Description of Reis."

8. Extract from "Hassler's Technical Physics," a book published at Vienna in 1866, Vol. I., page 648, marked "No. 8, Hassler's Description of Reis."

9. Extract from Atkinson's translation of "Ganot's Physics," eighth edition, 1877, page 757, the French edition of which was published at Paris in , marked "No. 9, Ganot's First Description of Reis."

10. Extract from Atkinson's ninth edition of the same book, published in New York in 1869, page 773, marked "No. 10, Ganot's Second Description of Reis."

11. Extract from a book called "Electricity," by R. M. Ferguson, published in London and Edinburgh in 1867, pages 257, 258 marked "No. 11, Ferguson's Description of Reis."

12. Extract from a book by Prof. A. E. Dolbear, called "The Telephone," published in Boston in 1877, pages 103, 104, marked "No. 12, Dolbear's Description of Reis."

13. Extract from the Journal of the Literary and Philosophical Society of Manchester, England, for Nov. 10, 1864, and marked "No. 13, Clifton's Description of Reis."

14. Extract from Du Moncel's "Applications de l'Electricité," Vol. II., page 255, published in Paris in 1854, marked "No. 14, Bourseul Article."

15. Extract from "Comptes Rendus," for Nov. 27, 1877, a book published in Paris, marked "Du Moncel Article."

16. The complainants put in evidence a paper signed by President Morton, and referred to in his fifty-seventh cross-interrogatory and answer, and a copy thereof, marked "No. 16, President Morton's Letter," is put in evidence, the original to be produced at the hearing.

[*The defendants' counsel objects to each and every one of the publications above put in evidence, as incompetent and immaterial, because the statements of the several authors or writers, in the said several publications, are not competent evidence of any of the supposed facts stated by them, nor are they competent as proof of the mode of operation of the instruments therein described, and because the opinions of such authors or writers are immaterial, and the said publications are incompetent as evidence of any opinion said to have been held by them.*]

17. Complainants' counsel also puts in evidence the record in the suit of the Bell Telephone Company *et al. v.* Dowd, to wit: the pleadings, the decree, and also the consent filed in the cause before the decree was entered, the said consent being marked "No. 17, Consent in Dowd Suit."

[*Defendants' counsel objects to said record as introduced, because the same is incomplete, consisting only of the pleadings, consent to decree, and decree; and because the same does not show the evidence taken in said case or the proceedings therein; the evidence which has been introduced herein from said Dowd case being only a portion of such evidence, and being introduced here as original evidence in this case, and to save the time and expense of retaking the same. Defendants' counsel further objects to all of the pleadings, proceedings and evidence in said Dowd case as incompetent as against these defendants, they not being parties thereto.*]

18. Complainants, not admitting the validity of the preceding objections, put in evidence, *de bene*, the copy of the whole of the record in said suit of Bell Telephone Company *et al. v.* Dowd, including all the evidence therein.

[*Last objection of defendants' counsel continued.*]

Attest: GEORGE H. EVANS, *Special Examiner.*

## AFFIDAVIT OF CHARLES R. CROSS.

[ATTACHED TO PAPERS NUMBERED 4 TO 15 INCLUSIVE.]

I, Charles R. Cross, on oath, depose and say: I have already testified in this case. I can read and understand the German and French languages. I have prepared or revised, at the request of the complainants, translations of the following articles: —

Article by Philip Reis, on pages 241 and 242 of the book entitled "Die Neueren Apparate der Akustik, von Dr. Fr. Jos. Pisco," published at Vienna, 1865. Article in "Dingler's Polytecnic Journal," Vol. CLXVIII., page 185, published in 1863. Article by M. St. Edmé, from the book called "Cosmos," Vol. XXIV., pages 349–352, published at Paris, 1864. This translation was compared with a copy which, I am informed and believe, was made from the original in the Astor Library, New York.

Description of the Reis telephone as made by Koenig, found in Koenig's catalogue of apparatus for 1865, published in Paris, 1865.

Description of Bourseul's ideas found in Du Moncel's "Applications de l'Electricité," Vol. II., page 225, published in Paris in 1854. This translation is copied from a translation thereof in Du Moncel's recent book on the telephone, published in New York by Harper & Brothers in 1880.

A paper by Du Moncel in "Comptes Rendus," dated Nov. 27, 1877, and published in Paris at or about that time.

Said translations are correct.

CHAS. R. CROSS.

COMMONWEALTH OF MASSACHUSETTS,
SUFFOLK, ss.

BOSTON, May 9, 1881.

Personally appeared before me the above-named Chas. R. Cross, and made oath that the above statement, by him subscribed in my presence, is true.

[SEAL]

WM. H. H. ANDREWS,
*Notary Public.*

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## No. 4,—REIS PROSPECTUS.

*From "Die Neuren Apparate der Akustik," Vienna*, 1865, *by* F. J. PISKO, *p.* 241.

The prospectus may here be given which is given by the inventor, Herr Ph. Reis, with the apparatus finished by him, and constructed by the mechanicians, Herrn Albert, of Frankfort:—

TELEPHONE.—Each apparatus consists of two parts, as shown in Fig. 60, page 96, the telephone proper A and the receiver C. These two parts are to be placed at such a distance from each other, that singing or the sound of musical instruments can be heard from one station to the other in no way except through the apparatus itself.

Both parts are connected with each other, and with the battery B, as in the case of ordinary telegraphic instruments. The battery must be capable of actuating the armature of the electro-magnet at the station A (3–4 six-inch Bunsen elements are sufficient for a distance of several hundred feet).

The galvanic current goes from B to the contact piece *d*, then through the copper slip to the platinum plate at the middle of the membrane, then through the foot (at D, Fig. 60) of the angular piece to the screw *b*, in whose little concavity a drop of quicksilver is placed. From here the current goes through the little telegraphic apparatus *e-g*, then to the key at station C, and through the spiral over *i* back to B.

If now stray tones are produced before the sound tube S, the membrane and the little angular hammer resting upon it are set in motion, the circuit will for each complete vibration be once opened and again closed, and thus the iron wire in the spiral, at Station C, will be caused to produce the same number of vibrations, which are recognized there as a tone or accord. By the firm connection of the upper portion of the sound chest with the axis of the spiral, the tone at C is greatly strengthened.

Besides the human voice (according to my observations), the tones of good organ pipes from F to *c*, and the tones of the piano, can be reproduced equally well.

For this last purpose, A is to be placed in the sounding board of the piano (of 13 triads a skillful experimenter could recognize 10 readily).

The telegraphic apparatus represented at the side is not needed for the reproduction of tones; but it furnishes useful results in ordinary experiments; though thus it is possible to communicate readily and surely with one at the further end of the line.

It can be done in the following simple way:—

After the apparatus is completely arranged, the operator assures himself of the certainty of the circuit and the strength of the battery by opening and closing the circuit, so that at A a striking of the armature and at C a very characteristic clicking of the spiral will be heard.

By rapid and successive "makes" and "breaks" of the circuit at A, C can be asked if everything is ready for the experiment, to which C can answer in the same way.

Simple signs can now be given at will between the two stations, by 1, 2, 3, 4, "breaks" and "makes" of the circuit; for example:—

1 blow = singing.
2 blows = speaking, etc.

I telegraph words by numbering the letters of the alphabet, and communicating their numbers:—

1 blow = a
2 blows = b
3 " = c
4 " = d
5 " = e,—and so on.

z would be designated by twenty-five blows. This number of blows would be troublesome and troublesome to count, so that for each five blows I give a "dactyl-blow," so that it gives

——— 00 for e.
——— 00 and 1 blow for f, etc.

z = 00 — 00 — 00 — 00 — 00

is quicker and easier to produce and easier to understand.

It is still better to designate the letters of the alphabet by numbers which can be interchanged.

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## No. 5,—DINGLER'S DESCRIPTION OF REIS.

"*Dingler's Polytechnic Journal*," *Vol. CLXVIII., Anno* 1863, *page* 185. *On the transmission of Tones at any desired Distance, by Means of Electricity.* (*Telephony.*) (*From* "*Böttger's Polytechnisches Notizblatt*," 1863, *No.* 6.)

Two decades ago the problem of giving signs by means of electricity, from distances, had not yet been entirely solved. Since then telegraphy has reached a perfection and telegraph wires have so greatly spread that even the keenest desires have not much left to ask for.

Now there appears a first earnest trial to reproduce tones at any desired distance, by means of electricity.

This first trial, which has been crowned with success, has been repeated in the lecture room of the Physical Society of Frankfort-on-the Main, before numerous assembled members, on the 26th of October, 1861, by Mr. Ph. Reis, teacher of natural sciences at Friedrichsdorf, near Frankfort. Into one part of his apparatus, located in a building about three hundred feet distant, and having all the doors and windows closed, melodies were sung, but not very loudly. The same could be heard by the members in the lecture room, through the second part of the apparatus.

These wonderful results were attained with the following very simple apparatus: A small, light box, a kind of hollow wooden cube, has a larger opening in the front, and a smaller one on the opposite side. The latter is covered with a very fine membrane, (sausage skin,) and the same is tightly stretched; a small, flexible piece or strip of platina, fastened to the wood of the box, touches the membrane at its center, and a second strip of platina is fastened by one end to the wood at a different place, and has at its other end a fine horizontal point touching the other strip of platina, where it lies on the membrane.

As is known, tones are produced by the rapid succession of compressions and rarefactions of the air. If the vibrations of the air, called waves, strike the thin membrane, they push the same against the strip of platina that touches it, and then allow it to immediately vibrate back

into the hollow cube (called the artificial ear), and so cause the membrane to assume forms alternately bent towards the cube and from the same. The strip of platina lying against the membrane is thus set into a swinging motion, so that it is alternately pressed on to the second strip and then leaves the same.

If one of the strips is connected by a wire to one of the poles of a voltaic battery, and the electricity is conducted to any desired distance by a wire connected to the other pole and is then carried through a helix six inches in length, formed by the sixfold winding of a thin silk-covered copper wire. and from there is carried back to the second strip of platina on the wooden cube by means of an insulated wire; then, at every vibration of the membrane, an interruption of the current of electricity will be caused, as the point on the one strip of platina no longer touches the other strip. Through the hollow of the spiral a thin iron wire (a thick knitting needle) about ten inches in length is passed, so that it projects out of each end of the spiral about two inches, and these projecting ends each rest on a bridge of a sounding board.

It is known that if an electric current is passed through a helix that surrounds an iron wire, at every interruption of the current a tone, produced by the vibrations of the iron wire, is audible. If the interruptions and reconnections of the current follow each other proportionately slowly, the different positions (in regard to the length of the bar) the molecules will be caused to assume by the electricity will produce a tone, its so-called proper longitudinal tone, which depends on the length and thickness of the bar or wire.

If the interruptions and reconnections of the current in the spiral take place faster than the vibrations of the smallest parts of the wire, which in turn depends upon the elasticity of the wire, they cannot complete their course, receive new shocks, the vibrations get to be smaller but more rapid, and as numerous as the interruptions follow each other. The piece of wire no longer gives its longitudinal tone, but a tone which, according to the number of interruptions in a certain time, is higher if they are more frequent and lower if they are less frequent. It is known that the pitch of a tone depends on the number of air waves that follow each other in one second. We have seen that the number of interruptions of the electric current by the membrane and the strips of platina is dependent upon this.

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Consequently the iron wire must give a tone of the same pitch as the sound which was received by the membrane. As electricity is hardly impaired when conducted a great distance, if the proper apparatus is used, it is evident that a tone acting on a membrane in one place can be made audible at any desired distance by the iron wire.

That the tone is made audible only by electric vibrations and not by direct transmission of the air waves through the wires, can be most strikingly proved by noticing the fact that no tone is heard at the spiral if a good short circuit be established; *i. e.*, if, for instance, a small strip of metal is laid across the two wires, directly in front of the spiral, the reproduced tones are weaker than the originals, but the number of vibratrations is the same.

It is easy to reproduce the tones in the proper pitch. As the vibrations are smaller, which is the cause of the weakness of the tone, it is much more difficult, however, for our ear to estimate the difference in the size of the vibrations.

The character of a tone depends upon the number of swellings it has; *i. e.*, upon tones of the same depth, consequently of the same number of waves per second, such as having the fourth, sixth, eighth, tenth or sixteenth wave stronger than the rest.

The physicists have shown that if a spring is vibrated by the teeth of a cog wheel, the first vibration is the greatest, and every following one is smaller. If, however, before the spring gets to rest, another tooth strikes it, then the next vibration will be equal to the first strongest one, but the spring will not make any more vibrations than before. Vowel tones can be artificially produced in this way.

If we are not so far advanced that we can converse with a friend a hundred miles away and yet recognize his voice, as though he was sitting alongside of us, the impossibility of attaining this result can no more be claimed.

The probability that this result will be attained is almost as great as, by the wonderful experiments of Niepce, the reproduction of natural colors by photography.

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## No. 6,—COSMOS DESCRIPTION OF REIS.

*"Cosmos," by l'Abbé Moigno, Vol. XXIV., pages* 349, 352. *Printed and published at Paris, March* 22, 1864.

GENERAL PHYSICS: ACOUSTICS.

*The Acoustic Telegraph or Telephone of Mr. Philip Reis.*

In 1837 Mr. Page observed for the first time the phenomenon of the production of sound by electricity, when the poles of a magnet were rapidly brought near to and moved away from a helix or conducting wire through which an electrical current was passing. M. Delezelle produced an analogous effect by turning an armature of soft iron before the poles of a magnet. The particular phenomenon with a helix was observed separately by M. de le Rive and M. Beatson Marriani. Each of these physicists made upon this subject their own special remarks. M. de le Rive attributed the sound produced to the kind of shock which took place upon the sudden displacement of the molecules at the moment when the current produced its appropriate action. It would therefore be possible to increase the intensity of the effect produced, by multiplying the intermittences in the passage of the current. It is in this way that the learned professor of Geneva was able to produce a sound both clear and prolonged, from a cylindrical mass of iron ten centimetres in diameter and weighing ten kilogrammes. M. Marriani recognized, on his part, that the sound created by a bar of iron placed in these conditions was the same as that which it would give forth if it was thrown into vibration by blows which affected it at its extremity. None of the magnetic metals produced any effect of the kind. As to the coercitive force, M. Marriani establishes that a bar of steel, well tempered, would make no sound, but that on the contrary the phenomena manifested itself when it was annealed. M. Marriani and M. de le Rive observed also that an intermittent current passed through a stretched wire, made it produce a sound identical with that which it would give forth if it were placed in the interior of a helix. According to M. de le Rive the sound was more intense as the wire was made

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shorter, and according as its electrical resistance came nearer to that of the battery employed.

Mr. Wertheim rendered sensible to the ear the vibrations which result from the passage of a discontinuous electric current through a rigid bar.

In these various experiments, in addition to the musical sound, the observer perceived a succession of blows (*battement*) which coincided with the interruptions of the current. M. de le Rive compared them to the noise which drops of rain made on falling upon a metal roof. These successive blows would even be obtained on operating upon magnetic metals reduced to a powder. M. de le Rive explains this: the sound produced by iron when the current passes in the magnetizing helix is explained by M. de le Rive as follows:—

"The current tends to place the molecules of the iron in a longitudinal direction; these tend to return afterwards to their normal position, hence the vibrational movement which gives rise to the sound."

It is on the basis of these facts that Mr. Reis has constructed the telephone or acoustic telegraph. Fantastic minds have singularly exalted the qualities of this apparatus; they have undertaken to indicate for it at once an office which it is far from being able to fill. The exaggerations of these illusions have been demonstrated to us by experiments which we have just made at Mr. Koenig's establishment with an apparatus constructed in Germany, under the supervision of Mr. Reis. This physicist has constructed his telephone in the following manner:—

The transmitter (manipulator) is represented by a rectangular hollow box. One of the sides of this is provided with a flaring opening, intended to receive the note which was to be transmitted. The upper surface of it consists of a membrane suitably stretched, on the center of which is fixed a strip of platinum, which is in electrical connection with one of the poles of the battery. Above this there is placed a second and movable strip which, when the instrument is not in operation, rests on the first by a fine point, making contact by a fine point also of platinum. It will readily be understood that if the membrane vibrates, it will throw up into the air the movable strip, which will again fall back into place. Hence oscillations which will correspond in number exactly with those of the membrane. The receiver is composed simply of a magnetizing

helix, in the interior of which is placed a bar of soft iron; the whole is mounted on a resonating box. When the apparatus is to be operated, these two instruments are placed in the circuit with an ordinary line battery. The operation of the instrument is easy to understand. The vibrations which the operator placed in front of the mouthpiece impresses upon the air enclosed in the box of the transmitter are repeated by the membrane; and just as a style fixed on this membrance (as in the phonautograph) would write these vibrations upon a paper covered with lampblack, so in the same manner the electrical contacts are successively established and broken between the two strips of platinum. Hence, there is caused in the coil of the receiver a number of intermittences or interruptions in the passage of the current, which is necessarily equal to the number of vibrations of the membrane of the transmitter. Now, since each intermittation causes one single shock, a series must necessarily produce a sound identical in pitch with that produced at the mouthpiece of the transmitter. Would not the telephone of Mr. Reis be an admirable instrument if it realized absolutely the promises which its theory holds out? Without prejudging the future, we must recognize that it has not yet done so. When one sings the musical scale at the transmitter, there needs an ear well trained to distinguish the sound repeated by the receiver in the midst of the vibrations which agitate it. For ourselves we have been only able to recognize the successive rise and pitch of these rapid roulades; but perhaps a trained musician would be able to recognize amongst them a dominant note. The model however of which we speak did not, and had in its construction several causes of error; and Mr. Koenig, so justly recognized in matters of acoustics, intends to study out the improvements of which this telephone is susceptible.

Let us mention some of the principal of these causes of error: It may be that the membrane will not at every moment vibrate with the same degree of amplitude, and this will consequently occasion sometimes a failure to make contact; if the sound produced by the operator at the transmitting end does not vary much, the contact may be prolonged. The remedy for this defect is in substituting for the voice of the operator a tuning fork, arranged to vibrate, for example by a

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battery; then a note would be produced which would be better defined, but always very feeble. As to improvements which would be of a nature to render this telegraphic apparatus practicable, Mr. Koenig is well fitted to find them. We already know certainly that the intensity of the sound increases as a softer iron is used, because in that case the molecules have more freedom of motion than they had in the hardened iron or in steel. If the iron core is magnetized by the influence of a permanent magnet, or by another coil, its sound is more intense when the intermittent current is sent in such a direction as to produce a demagnetizing effect upon it, and it is less intense when the current is sent through the helix in such a direction as to increase the magnetism. The reason is, that in this last case the molecules are in advance, in a position already very near that which the current can compel them to take. Too much tension in the core also makes the sound more feeble, for the molecules having been already placed in a forced position, are less free to receive further motion. The electrical transmission of musical sounds is therefore a problem, of which the true solution has not been found; and all the magnificent promises which have been made and published on the subject of acoustic telegraphy seem to us still to belong to the region of illusions.

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## No. 7,—KOENIG'S DESCRIPTION OF REIS.

*From* KOENIG'S "*Catalogue des Appareils d'Acoustique*," *Paris*, 1865, *page* 5.

29. TELEPHONE OF M. REIS. 60 FR.

This apparatus is intended to transmit sounds to a distance by means of electricity. It rests upon the fact demonstrated by the preceding apparatus. [*The preceding apparatus was the Wertheim coil and core, which Reis uses for a receiver.*]

At the first station the current traverses a little band of platinum, which is attached to a membrane in such a way as to follow all its movements, and of a very movable point, which rests lightly upon this membrane. At the other station the current traverses a coil, at the centre of which is a bar of soft iron. If now we produce before the mem-

brane a sound which causes it to vibrate, each vibration in pushing away the point from the platinum plate will produce an interruption of the current. On the other hand, each making of the current will produce in the bar of soft iron at the second station a momentary and weak sound. It is the rapid and isochronous succession of these slight sounds, all acting as simple blows, which produce the continuous sounds that are heard. It is true that they are not of good quality and that they cease from time to time. This comes from the fact that the membrane does not vibrate equally well for all tones, and because the manner in which the vibrations determine the interruption of the current, by pushing the little point away from the plate, is far from being perfect.

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## No. 8,—HASSLER'S DESCRIPTION OF REIS.

HASSLER'S *Technical Physics. Vienna*, 1866, *Vol. I, p.* 648.

The subject of phonotelegraphy will end this chapter. This rests upon a phenomenon first observed by Page, afterwards confirmed by Mariani, and more exactly studied and experimented upon by Wertheim; that is, that iron, under the influence of alternate magnetizing and demagnetizing by means of a galvanic helix, is set in longitudinal vibration and gives forth sound; and Reis showed beyond doubt the possibility of phonotelegraphy by means of an apparatus called by him telephone (Fig. 429), consisting of two parts,—the actual telephone (I), and the reproduction apparatus (II), used at the second station at a distance. Both parts are connected with one another and with a battery, *s*, as in ordinary telegraphs. The battery *s* must be strong enough to work the armature *a* of the electro magnets *e*, *e*, (three or four six-inch Bunsen's elements are sufficient for a distance of several hundred feet). The current passes from *s* to the binding screw 2, thence through the strip of copper *n* into the disk of platinum *o*, resting on the middle of a thin circular membrane (hog's gut), stretched across the upper end of the wooden box *k;* afterwards it goes through the foot (platinum point) of the metallic angle *a*, *b*, *c* (this point standing on the disk *o*), into a vertical screw, provided with a small cavity at its upper end containing

a drop of mercury, into which there dips from *a*, *a* a platinum point suspended above, while the angle *a*, *b*, *c* rests at *c* on a small metallic pillar, so as to be very easily made to vibrate about *a* and *c*. From this pillar (at *c*) the current goes through the key *t* and into the binding screw *i* connected with the wire leading to the pillar, thence through a wire stretched from this screw into the binding screw 3 on the apparatus 4, then through the key *t* of this apparatus into the bobbin *g* (magnetizing coil), inclosing the iron or steel wire *d*, *d* of the thickness of a knitting needle, into the binding screw 4, and finally thence by wire back to the second pole of the battery *s*. If, now, we produce sufficiently strong tones by means of organ pipes in front of the opening of the tube T (or sing them through the tube T in the hollow box *k*), the waves of the sound set the membrane *m* into regular vibrations. Every condensation occurring beneath *m*, at once raises the disk of platinum, *o*, together with the platinum point *b* (the foot of the angle *a*, *b*, *c*); when the rarefication occurs and *m* moves downward again, the angle *a*, *b*, *c* cannot immediately follow the disc *o*, and the current is interrupted, and a similar interruption occurs with every vibration of *m*, and in this way are produced just as many vibrations in the wire *d*, *d* of the coil *g*, at station II as the membrane makes; these vibrations are perceived there as tones and combination of tones (accords). These tones are much strengthened by covering the coils with a box of resonant wood, *d*, for a sounding board, so placed as to fit the sounding board, *b*, below the keys X and X, make it possible to communicate short messages as necessity arises, between stations I and II. (*E. g.*, to signify from II to I that they are ready to receive communications at II.) For by pressing down the keys the electro-magnet *e* is included in the circuit, the armature *a* drawn up and made to strike upon *e*.

The telephone is yet in its infancy, it is true, but even now, by employing powerful currents, it transmits at a distance not only solitary tones, but even tunes consisting of slow consecutive tones, quite perceptibly and distinctly.

## No. 9,—GANOT'S FIRST DESCRIPTION OF REIS.

GANOT'S *Elementary Treatise on Physics. 8th Edition. Translated by* E. ATKINSON. *N. Y.*, 1877, *p.* 757.

Reis's telephone consists essentially of a membrane which is put in vibration by producing musical sounds in front of a convenient mouthpiece. The apparatus is so arranged that these vibrations alternately open and close a current which produces at any distance sounds by such an arrangement as the above.

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## No. 10,—GANOT'S SECOND DESCRIPTION OF REIS.

GANOT'S *Elementary Treatise on Physics. 9th Edition. Translated by* E. ATKINSON. *N. Y.*, 1879, *p.* 773, REIS'S *Telephone.*

The essential features of this instrument (Fig. 729) are a sort of box *b*, one side of which is closed by a membrane *c*, while there is a mouthpiece *a* in another side. On the membrane is a piece of thin metal foil *e* which is connected with a wire leading to one pole of the battery *c z*, the other pole of which is put to earth. Just above the foil and almost touching it is a metal point *d*, which it connected by the line wire with one end of a coil of insulated wire surrounding an iron wire, the other end of which is put to earth.

When the mouthpiece is spoken or sung into, the sounds set the membrane in vibration; this alternately opens and closes the current; and these makes and breaks, being transmitted by the current to the electro magnet, produces the corresponding sounds.

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## No. 11,—FERGUSON'S DESCRIPTION OF REIS.

*Extract from Publication entitled "Electricity," by* ROBERT W. FERGUSON, *etc.*

ELECTRICITY.—R. W. FERGUSON, LONDON, 1867. PAGE 257. THE TELEPHONE.—"This is an instrument for telegraphing notes

of the same pitch. Any noise producing a single vibration of the air, when repeated regularly a certain number of times in the second (not less than thirty-two,) produces, as is well known, a musical sound. In Art. 115, we found that when a rod of iron was placed in a coil of insulated wire, and magnetized by a current being sent through the coil, it gave out a distinct tick when it was demagnetized by the stoppage of the current. A person when singing any note causes the air to vibrate so many times per second, the number varying with the pitch of the note he sings, the higher the note the greater being the number of vibrations. If we then, by any means can get these vibrations to break a closed circuit in which the coil just mentioned is included, the note sung at one station can be reproduced, at least so far as pitch is concerned, at another. Reis's telephone (invented 1861) accomplishes this in the following way: A A (Fig. 141) is a hollow wooden box with two round holes in it, one on the top, the other in front. The hole at the top is closed by a piece of bladder S, tightly stretched on a circular frame; a mouth piece M is attached to the front opening.

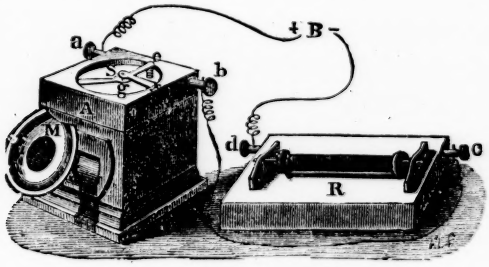


FIG. 141.

When a person sings in at the mouthpiece, the whole force of his voice is concentrated on the tight membrane, which in consequence vibrates with the voice. A thin strip of platinum is glued to the membrane, and connected with the binding screw *a*, in which a wire from the battery B is fixed. A tripod, *e f g*, rests on the skin. The feet, *e* and *f*, lie in metal cups, on the circular frame over which the skin is stretched. One of these, *f*, rests in a cup containing mercury, and is connected with the binding screw *b*. The third foot *g*, consisting of a platinum point, lies on the circular end of the strip of platinum just mentioned. This point, being placed on the center of the oscillating

membrane, acts like a hopper, and hops up and down with it. It is easy to understand how, for every vibration of the membrane, the hopper will be thrown up for the instant from connection with its support, and how the close circuit is thus broken at every vibration. The receiving apparatus R consists of a coil of wire placed in circuit, enclosing an iron wire, both being fixed on a sounding box. The connections of the various parts of the circuit are easily learned from the figure. Suppose a person to sing a note at the mouthpiece which produces three hundred vibrations a second, the circuit is broken by the bladder three hundred times, and the iron wire ticking at this rate gives out a note of the same pitch. The note is weak, and in quality resembles the sound of a toy trumpet. Dr. Wright uses a receiving apparatus of the following kind: The line current is made to pass through the primary coil of a small induction coil. In the secondary circuit he places two sheets of paper, silvered on one side, back to back, so as to act as a condenser. Each current that comes from the sounding apparatus produces a current in the secondary current which charges and discharges the condenser, each discharge being accompanied by a sound like the sharp tap of a small hammer. The musical notes are rendered by these electric discharges, and are loud enough to be heard in a large hall.

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## No. 12,—DOLBEAR'S DESCRIPTION OF REIS.

"*The Telephone*," *by* A. E. DOLBEAR, *page* 103.

### REIS'S TELEPHONE.

The ease with which membranes are thrown into vibrations corresponding in period to that of the sounding body has already been alluded to on page 80; and several attempts have been made, at different times, to make membranes available in telephony. The first of these attempts was made by Philip Reis, of Friedrichsdorf, Germany, in 1861.

His apparatus consisted of a hollow box, with two apertures; one in front, in which was inserted a short tube for producing the sound in, and indicated by the arrow in the cut, Fig. 12; the other on the

top. This was covered with the membrane *m*,—a piece of bladder stretched tight over it. Upon the middle of the membrane a thin piece of platinum was glued; and this piece of platinum was connected by a wire to a screw-cup from which another wire went to a battery.

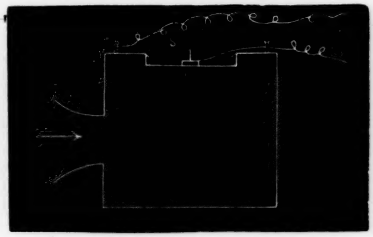

Fig. 12.

A platinum finger, S rested upon the strip of platinum, but was made fast at one end to the screw-cup that connected with the other wire from the battery. Now, when a sound is made in the box, the membrane is made to vibrate powerfully; this makes the platinum strip to strike as often upon the platinum finger, and as often to bound away from it, thus making and breaking the current the same number of times per second. If, then, a person sings into this box while it is in circuit with the aforementioned click-rod and box, the latter will evidently change its pitch as often as it is changed by the voice. In this apparatus we have a telephone with which a melody may be reproduced at a distance with distinctness. But the sounds are not loud, and they have a tin-trumpet quality. If one reflects upon the possibilities of such a mechanism, and upon the conditions necessary to produce a sound of any given quality, as that of the voice or of a musical instrument as described in preceding pages, he will understand that it can reproduce only pitch. It might here be inferred that something more than a single pitch is transmitted if the sound is like that of a tin-trumpet, as stated; but the reason of this is that, whenever a current is passing between two surfaces that can move only slightly on each other, there is always an irregularity in the conduction, so as to produce a kind of scratching sound; and it is this, combined with the other, the true pitch, that gives the character to the sound of this instrument.

Dr. Wright found that a sound of considerable intensity could be obtained by passing the interrupted current through the primary wire of a small induction coil, and placing a conductor made of two sheets of silvered paper placed back to back in the secondary circuit. The silvered paper becomes rapidly charged and discharged, making a sound that can be heard over a large hall, and having the same pitch as the sending instrument.

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## No. 13,—CLIFTON'S DESCRIPTION OF REIS.

*Proceedings of the Literary and Philosophical Society of Manchester. Published at Manchester*, 1865.

PHYSICAL AND MATHEMATICAL SECTION.

NOVEMBER 10, 1864.

Joseph Baxendell, F. R. A. S., president of the section in the chair.

Professor Clifton exhibited an acoustical electric telegraph by which a note, sounded at one end of the line, is reproduced at the other end.

He also pointed out the principles involved in the construction of this telegraph, viz:—

*First.* The production of a sound whenever a current of sufficient strength commences to circulate around an electro-magnet, or ceases so to circulate.

*Second.* The vibration of a stretched membrane in accordance with a note sounded near it.

With respect to the second principle, Professor Clifton drew attention to the fact that the researches of MM. Bourget and Bernard, in agreement with the mathematical investigations of Poisson and M. Lamé, show that a given square membrane will *not* vibrate in accord with *any note*, as stated by Savart. As the same is probably true of circular membranes, such as that used in this telegraph, it follows that only certain notes are capable of being transmitted by one instrument.

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## No. 14,—BOURSEUL ARTICLE.

Du Moncel's "*Exposé des Applications de l' Electricité*," Vol. II., page 225, published in Paris in 1854, contains the following: —

**[The translation is taken from the translated edition of Du Moncel's book on the "Telephone," which reproduces this notice.]**

After the telegraphic marvels, which can reproduce at a distance handwritings, or even more or less complicated drawings, it may appear impossible to penetrate farther into the region of the marvellous, yet we will try to advance a few steps farther. I have, for example, asked myself whether speech itself may not be transmitted by electricity; in a word, if what is spoken in Vienna may not be heard in Paris? The thing is practicable in this way: —

We know that sounds are made by vibrations, and are adapted to the ear by the same vibrations, which are reproduced by the intervening medium. But the intensity of the vibrations diminishes very rapidly with the distance; so that it is, even with the aid of speaking-tubes and trumpets, impossible to exceed somewhat narrow limits. Suppose that a man speaks near a movable disk, sufficiently flexible to lose none of the vibrations of the voice; that this disk alternately makes and breaks the currents from a battery; you may have at a distance another disk which will simultaneously execute the same vibrations.

It is true that the intensity of the sounds produced will be variable at the point of departure, at which the disk vibrates by means of the voice, and constant at the point of arrival, where it vibrates by means of electricity; but it has been shown that this does not change the sounds. It is, moreover, evident that the sounds will be reproduced at the same pitch.

The present state of acoustic science does not permit us to declare *a priori* if this will be precisely the case with syllables uttered by the human voice. The mode in which these syllables are produced has not yet been sufficiently investigated. It is true that we know that some are uttered by the teeth, others by the lips, etc.; but that is all.

However this may be, observe that the syllables can only reproduce upon the sense of hearing the vibrations of the intervening medium.

Reproduce precisely these vibrations, and you will produce precisely these syllables.

It is, at all events, impossible, in the present condition of science, to prove the impossibility of transmitting sound by electricity. Everything tends to show, on the contrary, that there is such a possibility. When the application of electro-magnetism to the transmission of messages was first discussed, a man of great scientific attainments treated the idea as utopian, and yet there is now direct communication between London and Vienna by means of a simple wire. Men declared it to be impossible, but so it is.

It need not be said that numerous applications of the highest importance will immediately arise from the transmission of speech by electricity. Any one who is not deaf and dumb may use this mode of transmission, which would require no apparatus except an electric battery, two vibrating disks and a wire. In many cases, as per example in large establishments, orders might be transmitted in this way, although transmission by electricity will not be used while it is necessary to go from letter to letter, and to make use of telegraphs which require use and apprenticeship. However this may be, it is certain that in a more or less distant future speech will be transmitted by electricity. *I have made some experiments in this direction.* They are delicate, and demand time and patience; but *the approximations obtained* promise a favorable result.

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## No. 15,—DU MONCEL ARTICLE.

In a paper by Du Moncel and published in *Comptes Rendus*, Nov. 26, 1877, he refers to this notice about Bourseul's plan, and adds:—

However this may be, the fact cannot be concealed that it is Mr. Bell who is the inventor of the telephone, for there is a whole world between a first idea and its definite realization. It is simply because Mr. Bell has made the intensity of the currents which transmit the vibrations of the voice, and correspond to the latter in their amplitude and their changes, that the problem has been solved.

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## No. 16,—PRESIDENT MORTON'S LETTER.

NEW YORK, April 7, 1877.

Professor A. GRAHAM BELL, *Boston University:*

*Dear Sir*,—The interest excited during the Centennial Exhibition by your experiments with your telephone, holding communications in audible speech with persons many miles away, and the published accounts of your improvements in the wonderful instrument, prompt us to request that you will deliver in our city, on some evening convenient to yourself, a lecture on sound and electricity, with an exhibition of your speaking telephone, showing what can be done by it, and making known its scientific and commercial value.

Very truly, etc.,

F. A. P. BARNARD.
HOWARD CROSBY.
HENRY MORTON.
E. L. YOUMANS.
CYRUS W. FIELD.
THOS. T. ECKERT.
A. M. MAYER.
WILLIAM ORTON.
J. S. NEWBERRY.
C. T. CHANDLER.
H. D. NOYES.
JNO. W. DRAPER.

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## No. 17,—CONSENT IN DOWD SUIT.

### UNITED STATES CIRCUIT COURT.

DISTRICT OF MASSACHUSETTS. OCTOBER TERM, 1880.

**No. 1040. In Equity.**

BELL TELEPHONE CO. ET AL., *v.* PETER A. DOWD.

### FINAL DECREE.

[APRIL 4, 1881.]

In this cause upon the bill, answer and replication, and the proofs taken and filed, and settlement having thereupon been made between the

parties upon considerations accepted by the plaintiffs, it it now, to wit, April 4, 1881, with the consent of the counsel of the parties respectively, ordered, adjudged and decreed that Alexander Graham Bell is the original and first inventor of the inventions specified in the fifth claim of the patent numbered 174,465, granted to said Bell, March 7, A. D. 1876, and the third, sixth, seventh and eighth claims of the patent numbered 186,787, granted to said Bell Jan. 30, 1877, being the claims in respect of which the proofs were taken; that the said patents are good and valid patents therefor; that the defendant has infringed the same; that he pay to the plaintiff the sum of one dollar in full satisfaction of profits, damages and costs, and that he be enjoined from further infringing the said patents.

By the Court,

JOHN G. STETSON, *Clerk.*

It is hereby consented that the annexed decree be entered.

GEO. GIFFORD,

*of Counsel for Defendant.*

BROWNE, HOLMES & BROWNE,

*of Counsel for Defendant.*

Approved:

J. LOWELL, *Circuit Judge.*

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## No. 2,—DEPOSITIONS OF BELL AND WATSON.

### DEPOSITION OF A. G. BELL.

ALEXANDER GRAHAM BELL, *being duly sworn, deposes and says:*

*Direct Examination by* Mr. STORROW.

*Int.* 1. Are you the patentee in this case? Did you give a deposition in the suit of the Bell Telephone Co. *v.* Dowd, the record of

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which has been put into this case; and are statements contained in that deposition true?

*Ans.* Yes.

*Cross-examined by* L. W. SERRELL, *of Counsel for T. A. Edison.*

*Cross-Int.* 2. When did you first make the instrument represented in Figs. 2 and 3 of your patent No. 186,787?

*Ans.* I do not quite understand whether you mean the actual and complete apparatus shown in Figs. 2 and 3, or instruments embodying the same features of construction though different in detail.

*Cross-Int.* 3. My question applies to the instrument just as it is shown there.

*Ans.* In October, 1876, I constructed the identical apparatus shown in Figs. 2 and 3 of said patent, although instruments embodying the different points of the apparatus had been constructed long before.

*Cross-Int.* 4. Does your testimony heretofore given refer to the instrument like said Figs. 2 and 3? If so, please tell what part refers to said instrument.

*Ans.* The Exhibit 42, on pages 85 and 86, Vol. II., and my answers 160 and 161, page 501, and 164th answer, page 502, of Vol. I., and I am not sure but some others, refer to instruments substantially similar to that shown in Figs. 2 and 3 of the said patent; indeed, one of the identical instruments figured on page 86, Vol. II., formed, with some modifications, the actual model filed in the Patent Office with the application for this patent.

In the apparatus illustrated in Fig. 3, page 86, an aperture H is shown in the top of the box B into which we spoke. It was found, upon experiment, that the large cavity inside the box B was disadvantageous in a transmitting telephone, when the voice was directed into its interior; but upon speaking against the outside of plate A of the figure in the exhibit, and covering up the mouth and plate A as much as possible with the hand, the articulation audible from the receiver connected with the instrument became much more distinct. This was noted on Nov. 12, 1876, in said Exhibit 42, in the following language: "Upon placing the mouth against the plate A and speaking, the sounds became perfectly distinct from the other telephone.

Upon condensing the air against the armature A by means of the hand, the utterance was perfectly distinct and quite as loud as when we spoke into the hole H. When we blew against A, Fig. 4, the sound was audible at Z."

In the instrument forming the model filed with my application for said patent, and which is illustrated in Figs. 1, 2 and 3 of said patent, the hole in the top of the box was covered up, the cover being shown at D, Fig. 2, and the mouthpiece and the air space in front of the diaphragm were added.

*Cross-Int.* 5. Previous to October, 1876, and the experiments referred to in Exhibit 42, had you made any telephone instrument in which there was a diaphragm fastened at its edges, an electro-magnet adjacent to that diaphragm, and a device for adjusting the position of the case of the magnet relatively to the diaphragm?

*Ans.* Yes, in June or July, 1875, I had an instrument made, a drawing of which is given as Exhibit 34 (figure before page 49½ of Vol. II.), referred to on pages 478, 479 of Vol. I.; and also between that day and October, 1876, made many others having the features specified.

*Cross-Int.* 6. When did you first use an iron diaphragm in connection with the electro-magnet in the telephone transmitter or receiver?

*Ans.* I refer to the instrument shown in Exhibit 40, being the "Centennial Iron Box Magnet Receiver"; the entire diaphragm of this was of iron. This was exhibited to the American Academy of Arts and Sciences, on the 10th of May, 1876, and at the Centennial Exhibition, in Philadelphia, in June, 1876. I refer to this on pages 496 and 497 of Vol. I. in my direct examination, also on pages 513, cross-answers 200 and 201. I think this was made about the end of March or the beginning of April, 1876.

Such an instrument was used as a transmitter on the 30th of June, 1876, and is referred to in the extracts from my note-books found on page 76 *et seq.*, Vol. II. The metallic diaphragm referred to in that note-book, under date of June 30, 1876, Vol. II., page 76, is the one shown as complainant's Exhibit 45, page 104, of Vol. II., referred to in my direct testimony, page 404, Vol. I. The figure shown in the extract from my note-book under date of July 3, 1876, and found on

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page 77, Vol. II., is the one similar to the Centennial box magnet receiver.

*Cross-Int.* 7. Had you, before March or April, 1876, used a metal diaphragm in connection with an electro-magnet and resonant case or tube?

*Ans.* I had not, in connection with a telephone, or in connection with any acoustic telegraph.

*Cross-Int.* 8. Who prepared the draft of the specification accompanying your patent No. 186,787?

*Ans.* I did part of it myself, and I do not remember who it was assisted me.

*Cross-Int.* 9. Did you examine the said specification and correct it where necessary, previous to executing the application for patent; or, in other words, is the specification of the said patent substantially the same as it was when you signed it on the 13th of January, 1877?

*Ans.* I do not remember the particulars in connection with the preparation of the application with any great distinctness. I presume it is the same as when I signed it, but the records of the office will show. I looked it over before signing it.

*Cross-Int.* 10. When did you discover the differences between the devices in your patent 174,465 and those in your patent 186,787, as set out in paragraphs 4 and 5 of the latter patent; viz., that the devices in the first patent were each adapted to a particular note or sound, and that the devices in the last patent were adapted to notes or sounds of any kind?

[*Objected to by Mr. Storrow as an entire misstatement of the scope, purpose and effect of the first patent, in this, that it attempts to apply to both kinds of apparatus contained in the first patent, viz.: Fig.* 5 *and Fig.* 7, *the remarks of the second patent which apply only to Fig.* 5; *and also omits to make reference to those remarks in the second patent which apply to the instruments in the first patent intended to be operated by the human voice.*

*Counsel for Edison replies that this question only calls attention to paragraphs* 4 *and* 5 *of the second patent, and that if there be a mistake of any kind it must be the fault of the second patent and not of the question.*

*Counsel for Mr. Bell objects again on the ground that Mr. Edison's coun*

*sel should not put his arguments into the form of a statement in his questions.*]

*Ans.* I think that the differences between the devices in my patent 174,465 and those in my patent 186,787 are not indicated in paragraphs 4 and 5 of the latter patent. The chief differences are indicated in paragraphs 6 and 7 of that patent, which read as follows:—

"In my patent No. 174,465, dated March 7, 1876, I have shown as one form of transmitting instrument a stretched membrane, to which the armature of an electro-magnet is attached, whereby motion can be imparted to the armature by the human voice, or by means of a musical instrument, or by sounds produced in any way.

"In accordance with my present invention, I substitute, for the membrane and armature shown in the transmitting and receiving instruments alluded to above, a plate of iron or steel capable of being thrown into vibration by sounds made in its neighborhood."

The question assumes that all the devices shown in the first patent were "each adapted to a particular note or sound," whereas the fact is that only a few of the devices shown were so adapted, and the improvements illustrated in my second patent are not so much improvements of these devices as assumed by the question, as improvements of the apparatus shown in Fig. 7 of my first patent, No. 174,465.

*Cross-Int.* 11. Are we, then, to understand that paragraph 4 of your second patent is intended to apply specially to the devices shown in Figs. 5 and 6 of your first patent?

*Ans.* Certainly.

*Cross-Int.* 12. Please compare the receiving portion of the instrument Fig. 5 of your first patent with the Reis telephone receiver shown in connection with the conical transmitters in Prescott's work on the Speaking Telephone (p. 10,) and state what differences, if any, there are between said devices as receivers.

*Ans.* So far as I can understand the operation and construction of the Reis receiver referred to, we have in this instrument a receiver adapted to respond to tones of different pitch, whereas in the receiver shown in Fig. 5 of my first patent we have an instrument designed to

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to respond forcibly to a tone of one particular pitch only. This is due to the different mechanical construction of the two.

*Cross-Int.* 13. The device shown in your second patent is intended then, is it not, as an improvement upon the first, so far as Figs. 5 and 6 of the first patent are concerned, to the extent that the device in the latter patent is intended to and will respond to various tones?

*Ans.* The device shown in the second patent is not an improvement of the device shown in Figs. 5 and 6 at all, as they differ in their very essence from one another, the receivers in Figs. 5 and 6 being intended to respond to certain fixed tones only, while the device in the second patent is intended to respond to all tones with equal facility, and even to produce simultaneously from the same receiver a number of tones of different pitch. Hence the receiver in the second patent can be employed in place of a number of receivers like those shown in Figs. 5 and 6 of the first patent, if it is preferred. We have here simply an alternative method, the functions of the apparatus in the second patent not being limited to this use.

*Cross-Int.* 14. Please refer to the statement of the second patent, at the bottom of page 60, Vol. I., commencing "if two persons speak simultaneously," etc., and state whether that is found in practice to be the fact.

*Ans.* It is.

*Cross-Int.* 15. Do I understand correctly that any telephonic electrical transmitting device may be used in connection with the receiver shown in your second patent, as spoken of in the middle part of page 61, Vol. I.?

*Ans.* Yes, any electrical transmitting device suitable for the purpose intended. For instance, if it be intended to transmit articulate speech, any form of electrical transmitting speaking telephone may be employed in connection with the receiver shown in the patent; and if musical tones are desired, any form of electrical musical transmitter may be used.

*Cross-Int.* 16. Is the box that encloses the adjustable magnet in Figs. 1, 2 and 3 of your second patent essential in the operation of the instrument?

*Ans.* It is not necessary, but advisable. When the instrument is

used as a receiving instrument without the box the listener is much more apt to be disturbed by external noises than when the metallic diaphragm is protected by the box. The whole woodwork of the apparatus acts also as a sounding box.

*Cross-Int.* 17. Please refer to the claims in your second patent, and state which one, if any, applies *solely* to a telephonic transmitting instrument.

*Ans.* In this patent the same instrument is used both as a receiver and transmitter, and the majority of the claims are applicable to the instrument, whether considered as a transmitter or a receiver. For this reason, also, none of the claims refer to the instrument as a transmitter alone.

*Cross-Int.* 18. Please compare Figs. 2 and 3 of your patent No. 186,787 with Fig. 2 of Edison's application, No. 148, and state whether or not you discover any substantial difference in the instruments themselves, referring, of course, to the description of Mr. Edison's instrument, if necessary.

*Ans.* The instruments are radically and entirely distinct, the object of Mr. Edison's apparatus being to make the instrument respond forcibly to some particular pitch of sound only, whereas in my instrument the object is to prevent the re-enforcement of any particular tone, and thus secure uniformity of sound for tones of all pitches and for articulate speech.

These objects are obtained in the two instruments in the following manner: In the case of Mr. Edison's instrument, the air chamber is so arranged as to form a resonator which will re-enforce some particular pitch of sound. It is arranged in the form of a telescopic tube, so that it can be adjusted to the particular pitch it is desired to re enforce. In the language of Mr. Edison, "The object of the tubes is to allow of the lengthening or shortening of the column of air in the resonant tube, so as to bring it in unison to the particular note or tone which it is desired to hear," so that the function of the instrument is purely and simply the same as the tuned reed receiver shown in Figs. 5 and 6 of my patent No. 174,465. In the case of my instrument, shown in Figs. 2 and 3 of my patent No. 186,787, the air space in front of the diaphragm is contracted as much as possible, so as to prevent it from acting as a resonator. Thus

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in mode of construction, as in function, the two instruments are radically different.

*Cross-Int.* 19. In the previous question, no reference was made to the operation of the two instruments. I now ask you whether or not the following parts in Fig. 2 and 3 of your second patent are not found in Fig. 2 of Edison's application No. 148, viz., an electro-magnet that is adjustable, an iron diaphragm in proximity to the cores of the same, and a case holding or supporting the edge of the iron diaphragm.

*Ans.* I would hardly term a resonator a "case." I think the word "case" applies properly to the box containing the electro-magnet shown in my second patent, but hardly applies to the resonator shown in Mr. Edison's application. The part of my instrument which would correspond to the resonator in Mr. Edison's instrument is the base of the mouthpiece, containing the narrow air space in front of the diaphragm, and it is not to this that the diaphragm is attached.

*Cross-Int.* 20. Do you not find, in both the cases inquired about, an electro-magnet, means for adjusting the same, a diaphragm, and a support for the edges of the diaphragm?

*Ans.* I do.

*Cross-Int.* 21. Please look at Figs. 1, 2 and 3 in your second patent, and state whether or not the air in the tube E will have any definite rate of vibration and serve like a resonator to amplify a corresponding tone.

*Ans.* It does not act in this manner when the ear of the listener closes the end of the tube in using the instrument as a receiver; and I do not think that under any circumstances a tube of that description could re-enforce any note that could be produced by the human voice, or that would be produced by other means for the purposes of my invention.

*Cross-Int.* 22. Have you ever tested the action of the column of air in this tube E with different musical tones, to see whether or not any one tone would be re-enforced?

*Ans.* I have not made special experiments to test this point, but can state from observation that I have not found practically that tones have been re enforced in my experiments. I have heard a piece of music pro-

duced by this instrument and I feel certain that my attention would have been arrested by any re-enforcement by the tube.

*Cross-Int.* 23. Have you ever made any test with such an instrument as that shown in Fig. 2 of Edison's application 148, to ascertain whether or not the reception of articulate speech would be materially interfered with by the resonant case?

*Ans.* I have made an experiment that I think bears upon this point. The apparatus shown in Fig. 3, page 86, of Vol. II., was used as a receiver by placing the ear near the hole H, in the top of the box B; in this construction of the instrument the box B acted as a resonator, and it was found that the articulation was much impaired by the resonance of the air in the cavity; so much so, indeed, that although the orifice H had been specially made for the purpose of being spoken into and listened at, we were accustomed to place the ear in close contact with the plate A and cover up the hole H.

*Cross-Int.* 24. When did you first know of the existence of Edison's patent No. 141,777, Aug. 12, 1873?

*Ans.* I do not know. I believe I had no knowledge of this patent until the Dowd suit was begun, in the autumn of 1878. I had no knowledge of such an invention at the time my patent No. 174,465 was taken out.

*Cross-Int.* 25. When, if at all, did you ever make use of any device, acting in an electric circuit, for varying the resistance; such, for instance, as mercury, or any other liquid, as named in your first patent, in the middle portion of page 53, Vol. I.?

*Ans.* I made use of a device acting on an electric circuit for varying the resistance, as covered by the clause referred to in my patent, within a few days after the 4th of May, 1875, upon which day I wrote a letter to Mr. Hubbard, which has been produced in evidence on page 464, Vol. I., describing the experiment I was then about to make. In this experiment a continuous current of electricity was passed through a vibrating wire. In regard to mercury or other liquids, I do not remember when I first used them, but I know that I made experiments with such liquids in March, 1876. On the 10th of May, 1876, I described speaking telephones operating to vary the resistance of a voltaic circuit. I refer to my paper read before the American Academy on that day, printed in

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the record, page 157, Vol. I. I cannot be sure that I used a liquid in a speaking telephone previously to March, 1876.

*Cross-Int.* 26. Do you know whether or not magneto transmitters, such as represented in either of your patents, are in general use for commercial purposes, or whether the carbon transmitter has generally taken the place of the magneto transmitter, specially on long lines?

*Ans.* Magneto transmitters, substantially like those described in my patents, are in universal use, although it is more customary to employ, in addition to these instruments, some form of carbon telephone, to increase the volume of sound. As I have stated above, in my answer, the same instrument serves for a transmitter and receiver; and although the instruments are now chiefly made use of as receivers, there is nothing to prevent them from being used as transmitters, and they frequently are so used. To make my meaning clear, I may say that if all the carbon telephones now in use were to be removed, the telephonic circuits otherwise being left unchanged, telephonic communication could be carried on just as before, by using the magneto instruments as transmitters as well as receivers; whereas if the magneto instruments now in use, substantially like those described in my patents, were to be removed from the circuits where they are now employed, the whole telephonic communication of the country would become disorganized.

*Cross-Int.* 27. What is the longest circuit upon which a magneto transmitter has been successfully employed, to your knowledge?

*Ans.* I have myself successfully employed a magneto transmitter on a circuit of about two hundred and fifty miles. The line used was one of the telegraph lines between Boston and New York. In experiments with artificial lines I have successfully used a magneto telephone through a resistance of 60,000 ohms. I think the experiment between Boston and New York was made before midsummer of 1877.

In the spring of 1877, I gave a lecture in Providence upon the telephone, and conversation was carried on by means of magneto transmitters and receivers, by members of the audience, with persons in Boston, about forty miles distant. A speech was shouted into the Boston telephone, and the sounds were so loudly reproduced by the telephone in

Providence that the tones of the speaker's voice were heard by many hundreds of people. The instruments used were the ordinary box instruments, like those shown in my second patent, in Figs. 5 and 6, mounted in a box substantially similar to those shown in Figs. 1, 2 and 3 of the second patent. The diaphragms used were of iron.

*Re-direct, by* Mr. STORROW.

*Int.* 28. You have indicated that when the box containing the telephone, and through which the sound waves passed, was so shaped and arranged as to be a resonator, or resonant box, it impaired the articulate quality of the word or syllable transmitted. I wish you would explain why it is that a resonator or cavity adapted to pick out and re-enforce a particular tone, to the exclusion of others, is not adapted to give the articulate quality of speech.

*Ans.* Referring to the statement of what characteristics of sound constitute quality, *timbre*, or articulation, given in Prof. Cross's deposition, page 391 and 392 of the Dowd suit, and particularly to his twenty-third answer, on page 392, the effect of such a resonator is to re-enforce some particular overtone, changing the relative intensities of the overtones, and thus changing the quality or articulate character of the sound.

[*Adjourned at* 4.30 *P. M., to Monday, Feb.* 28, *at* 10 *o'clock A. M.*]

WASHINGTON, Feb. 28, 1881.

10 *o'clock, A. M. Met pursuant to adjournment. Present as before.*

*Cross Examination of Mr. A. G. Bell continued, by* Col. GEORGE W. DYER, *of Counsel for Voelker.*

*Cross-Int.* 29. Referring to your preliminary statement in these interferences, filed Dec. 20, 1878, is the statement made therein, and found upon pages 8 and 9 in the volume of preliminary statements concerning an interview with Prof. Henry, a correct statement?

*Ans.* It is, to the best of my recollection. I would like to state, in regard to my preliminary statement, that the statements made therein were made from general recollection, and before I had had full access to papers and memoranda to refresh my recollection. I had been in Europe

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from August, 1877, and had returned only a very short time before the writing of the preliminary statement, in ill health. At the time the statement was written I was confined to my bed in the Massachusetts General Hospital, in Boston. I understood that it was important to have the preliminary statement prepared by a certain day, and so did my best by dictating the preliminary statement to which attention has been called.

*Cross-Int.* 30. Have you any doubt of the correctness of the statement found in the first paragraph at the top of page 9 of the preliminary statements, commencing with the words "I had previously"?

*Ans.* No. I think it is correct; I do not recollect just now whether it was the receiving instrument of Reis's telephone I saw at the Institute of Technology, or the transmitting instrument. I remember perfectly that I saw one at the Institute of Technology and the other at the Smithsonian Institute; and I presume my statement is correct, as my memory was more fresh at the time the statement was made. In regard to the rest of the paragraph I feel perfectly certain.

*Cross-Int.* 31. Was this interview with Prof. Henry, at the time you saw the Reis telephone at the Smithsonian, the same interview referred to in your letter of March 18, 1875, found on page 459 of Vol. I. of the record of the Dowd suit?

*Ans.* It is.

*Cross-Int.* 32. About how long before the date of that letter did the interview referred to take place?

*Ans.* The letter was written on the 18th of March, 1875, and the interview referred to took place about the end of February or the beginning of March.

*Cross-Int.* 33. Do you remember whether the Reis telephone, which you had seen in the Institute of Technology, in Boston, was like either of those illustrated in Prescott's telephone book; and if so, which one?

*Ans.* Yes; it was like the receiver connected with the box form of the Reis transmitter. It is shown at "R," Fig. 141, on page 703 of the second volume of the record of the Dowd suit, in an extract from "Ferguson's Electricity."

*Cross-Int.* 34. How about the telephone at the Smithsonian?

*Ans.* It was like the box form shown in the same figure.

*Cross-Int.* 35. If I understand your testimony, you regard an undulatory action in electricity as essential to the operation of the speaking telephone in transmitting and receiving articulate language?

*Ans.* Certainly.

*Cross-Int.* 36. Did the speaking telephones you exhibited at Philadelphia on the twenty-fifth day of June, 1876, and referred to in answers to Ints. 133 and 134 of your testimony in the Dowd suit, pages 493 and 494, Vol. I., have this undulatory action; and by what construction of the instruments was the particular action effected?

*Ans.* Yes, they did. There were four forms of speaking telephones shown. Two of these, shown as Exhibits 38 and 39, could be used as transmitters or receivers. These were magneto instruments. Another instrument, shown as Exhibit No. 40, could be used only as a receiving instrument; and the fourth instrument, shown as Exhibit No. 41, could be used only as a transmitter. This was a liquid transmitter. One of the magneto instruments, shown as Exhibits Nos. 38 and 39, was used as a transmitter in connection with the receiver shown in Exhibit No. 40 in actually transmitting speech on that occasion. The undulatory action was affected by the to-and-fro motion of the steel spring armature attached to the membrane of the transmitter in front of the electromagnet.

*Cross-Int.* 37. If a Reis telephone, made in accordance with the descriptions published before the earliest dates of your invention, would in use transmit and receive articulate speech as perfectly as the instruments did which were used by you on June 25, 1876, at the Centennial, would it be proof to you that such Reis telephones operated by the use of undulatory movements of electricity in substantially the same way as your instruments did upon the occasion referred to?

[*Objected to by Mr. Storrow, on the ground that the question is based on a supposition as to the operation and result of the Reis instrument, which is unfounded.*]

*Ans.* The supposition contained in the question cannot be supposed. Were the question put that if I were to hear an instrument

give forth articulate speech transmitted electrically as perfectly as my instruments did on the occasion referred to in the question, I would hold this as proof that the instrument had been operated by undulatory movements of electricity, I would unhesitatingly answer, Yes.

*Re-direct, by* Mr. STORROW.

*Int.* 38. Please look at the letter of March 18, 1875, written to your father and mother, page 459, Vol. I., of the Dowd record, and which you have testified was written about three weeks after the interview therein referred to, and tell me whether, at the time you wrote that letter, you knew that the conversation between you and Prof. Henry on that occasion, which is there stated, was therein stated with substantial accuracy.

*Ans.* Yes, certainly.

*Int.* 39. I wish you would compare your magneto telephones, which are in commercial use to-day, with the magneto telephones which you used at the Centennial, on June 25, 1876, and tell me whether those of to-day do or do not practically transmit speech with greater perfection than those used at the Centennial.

[*Objected to by Mr. Dyer as being not proper re-examination, being new matter not brought out in cross examination.*]

*Ans.* They do transmit speech with greater perfection.

*Int.* 40. Will you tell me whether the difference between them which leads to this difference in practical results consists in a change in the mode of operation from that described in your patent 174,465, and set forth in the report of the Centennial judges, or whether it consists in improvements in the construction of the instruments without change in the mode of operation?

[*Previous objection is repeated.*

*Counsel for Mr. Bell states that he puts these two questions because he considers that they relate to matters opened by the cross examination and also because they are proper evidence in the nature of rebuttal.*]

*Ans.* It consists in improvements in the construction of the instruments without change in the mode of operation.

[*Cross examination waived by Mr. Baldwin.*]

ALEXANDER GRAHAM BELL.

Attest: PHILIP MAURO, *Notary Public.*

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# FURTHER EVIDENCE FOR A. G. BELL.

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## DEPOSITION OF THOMAS A. WATSON.

THOMAS A. WATSON, *being duly sworn, deposes and says, in answer to Interrogatories proposed to him by* J. J. STORROW, Esq., *of Counsel for A. G Bell, as follows:*

*Int.* 1. State your name, age, residence, and occupation; and have you testified in the case of Bell Telephone Company *v.* Dowd, and is your testimony in that case true?

*Ans.* Thomas A. Watson; twenty-seven years old; I live in Everett, Mass., and am an electrical engineer. I have charge of the electrical and technical department of the American Bell Telephone Company, including the manufacture of instruments. I have testified in the case mentioned, and my testimony is true.

*Int.* 2. Will you state how long you have been engaged in manufacturing or superintending the manufacturing of electrical speaking telephones for Mr. Bell and his licensees; and how intimately you have been acquainted with the growth and development of that business?

*Ans.* I have been engaged in the manufacture of telephones since the summer of 1875. All telephones that have been made for Mr. Bell and his associates have been manufactured under my supervision, with the exception of those made by the American Speaking Telephone Company, which are now in my charge.

*Int.* 3. Will you state how many electric speaking telephone patents were issued in 1876 in the United States?

*Ans.* Only one; that of Mr. Bell, No. 174,465, of March 7, 1876.

*Int.* 4. How many in 1877?

*Ans.* Three: one of Bell, Jan. 30, 1877, No. 186,787; and two of McTighe,—one Nov. 20, 1877, and one Dec. 18, 1877.

*Int.* 5. Can you tell me about how many patents on or relating to speaking telephones have been issued in the United States since then?

*Ans.* About one hundred and fifty.

*Int.* 6. How many patents for appliances especially adapted to be used in connection with speaking telephones, such as telephone calls, switches, etc., have been issued in the United States since Mr. Bell's first patent?

*Ans.* About one hundred and thirty.

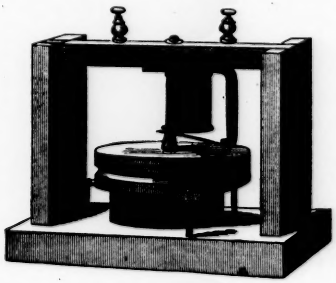
*Int.* 7. Please to state whether or not you assisted Mr. Bell in his early exhibitions or most of his exhibitions of his electric speaking telephone in 1876 and the first half of 1877; and whether you personally made or supervised the manufacture of the electric speaking telephones used by him on those occasions.

*Ans.* I assisted him at nearly all his exhibitions during 1876 and 1877, and I made nearly all of the telephones used at these exhibitions.

*Int.* 8. Please state the principal exertions and progress made by Mr. Bell and his associates in 1876 in the use of his electric speaking telephone in public and in introducing it to public attention: and give as part of your answer any newspaper or other publications of that period, which mark or indicate the progress made, the publicity given to his invention and the manner in which it was received by the community.

*Ans.* I first produce a drawing of the instrument made by me for Mr. Bell, according to his direction, June 2, 1875. It is referred to on pages 473 and 539 of the record in the Dowd suit: —

**BELL TELEPHONE OF 1875.**



DIMENSIONS.

| | | |
|---|---|---|
| Diameter of membrane | 4 | inches. |
| Diameter of spool | $1\frac{1}{4}$ | " |
| Length of spool | $1\frac{1}{2}$ | " |
| Length of armature | 2 | " |
| Width of armature | $\frac{1}{2}$ | " |
| Depth of tube from mouth to membrane | 3 | " |

May 10, 1876, a description by Professor Bell of his researches in telephony was read before the American Academy of Arts and Sciences, at Boston. This paper was published soon afterwards, and contained a description of his electrical speaking telephone, as shown in Fig. 7 of said patent, No. 174,465; and described the transmission of speech by it. It also contained a description of an electrical speaking telephone made upon the plan of varying the resistance of an electrical circuit supplied with a constant electro-motive force from a battery; the particular form indicated was that known as the liquid transmitter, referred to in said specification, and was described as follows:

"A platinum wire, attached to a stretched membrane, completed a voltaic circuit by dipping into water. Upon speaking to the membrane, articulate sounds proceeded from the telephone in the distant room. The sounds produced by the telephone became louder when dilute sulphuric acid or a saturated solution of salt was substituted for the water. Audible effects were also produced by the vibration of plumbago in mercury, in a solution of bichromate of potash, in salt and water, in dilute sulphuric acid and in pure water."

This was published in Vol. XII. of their proceedings.

Two sets of Professor Bell's speaking telephones were made by me for exhibition at the Centennial Exhibition in Philadelphia, and were exhibited there in June, 1876, before the judges of the group and many other persons. They consisted of a "magneto" transmitter and receiver, and of a liquid transmitter. I saw them there on exhibition.

They are referred to on pages 493, 544, 558, of the Dowd record. I produce drawings of these instruments as follows:

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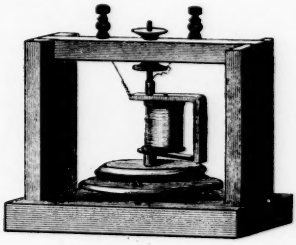
## COMPLAINANTS' EXHIBIT NO. 34, SECOND BELL TELEPHONE OF 1875, DUPLICATE.

(RECORD IN "DOWD CASE," PAGE 479.)

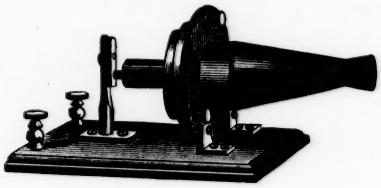


DIMENSIONS.

| | | |
|---|---|---|
| Diameter of membrane | $2\frac{3}{4}$ | inches. |
| Diameter of spool | $1\frac{1}{4}$ | " |
| Length of spool | $1\frac{1}{2}$ | " |
| Length of armature | 2 | " |
| Width of armature | $\frac{1}{2}$ | " |

## BELL'S SINGLE POLE CENTENNIAL MEMBRANE TELEPHONE.

409'1



DIMENSIONS.

| | |
|---|---|
| Length of cone | $5\frac{3}{4}$ inches. |
| Diameter of membrane | 3 " |
| Length of spool | $1\frac{3}{4}$ " |
| Diameter of spool | $1\frac{3}{8}$ " |

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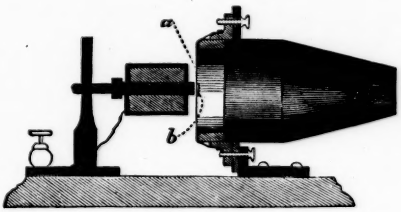
## SINGLE POLE CENTENNIAL MEMBRANE TELEPHONE.

(Sectional View.)




*a* Stretched membrane.
*b* Steel spring armature.

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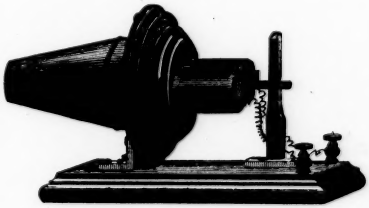
## BELL'S DOUBLE POLE CENTENNIAL MEMBRANE TELEPHONE.



DIMENSIONS.

| | |
|---|---|
| Length of cone | $4\frac{3}{4}$ inches. |
| Diameter of membrane | " |
| Length of spools | $1\frac{3}{4}$ " |
| Diameter of spools | $1\frac{3}{8}$ " |

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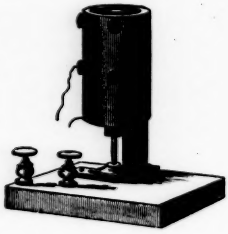
## BELL'S CENTENNIAL IRON BOX MAGNET RECEIVER.



DIMENSIONS.

| | |
|---|---|
| Diameter of tube . . . . . | $1\frac{3}{4}$ inches. |
| Length of tube . . . . . | 3 " |

The diaphragm consisted of a soft iron disk laid loosely over the top. It has since been lost.

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## BELL'S CENTENNIAL LIQUID TRANSMITTER.

DIMENSIONS.

| | |
|---|---|
| Diameter of membrane . . . . . | 3 inches. |
| Diameter of cup . . . . . | $\frac{3}{4}$ " |
| Depth of cup . . . . . | $\frac{1}{2}$ " |
| Length of cone . . . . . | 6 " |

The depositions of Mr. A. G. Bell and of Mr. William Hubbard, and of Mr. Elisha Gray, in the suit *Bell Telephone Company* v. *Dowd*, in the United States Circuit Court for the District of Massachusetts, describe one public exhibition of the transmission of articulate speech by them, on June 25, 1876.

Two reports were made upon Mr. Bell's said exhibit. One, by Professor JOSEPH HENRY, in "General Report of Judges of Centennial Exhibition, Group XXV.," pages 20 and 21, describes the apparatus and the transmission of speech by it, and is as follows:

General Report of Judges of Centennial Exhibition Group XXV., pages 20 and 21.

## THE ELECTRIC TELEPHONE AND MULTIPLE TELEGRAPH.

"The idea of transmitting sounds to a distance by means of electrical currents has been for several years before the world, and the idea of extension of this to telegraphy was evident, though no one had thought it could lead to practical results. But the idea of a multiple electrophonic telegraph transmitting simultaneously several different musical notes for the simultaneous transmission of different messages by one wire, is an invention of high scientific character promising admirable practical results. For the honor of this invention there are two claimants, Mr. Elisha Gray, of Chicago, Illinois, and Mr. Alexander G. Bell, of Salem, Massachusetts. These inventions are independent of one another and different in the method of producing the result. In the telegraph of Mr. Gray several series of waves or impulses are simultaneously transmitted through a single wire. These impulses are excited by interruptions in the current produced by tuning-forks of different pitches, and excite, at the farther extremity of the line, corresponding variations in tuning-forks of the same pitch. Thus, if four or five tuning-forks are vibrated at the same time at one end of a line, each will excite vibrations in its corresponding fork at the other end without effecting the other forks. The exhibitors of this telegraph inform the judges that they are now able to equip lines for actual business with a capacity for carrying, through one wire, eight messages simultaneously, and there is no reason why the number may not be increased to sixteen. This telegraph may be made self-recording, or may be worked forward by re-

lays through greater lengths of line than the insulation allows in one circuit.

"The telephone of Mr. Bell aims at a still more remarkable result,—that of transmitting audible speech through long telegraphic lines. In the improved instrument the result is produced with striking effect, without the employment of an electrical current other than that produced by the mechanical action of the impulse of the breath as it issues from the lungs in producing articulate sounds. To understand this wonderful result, suppose a plate of sheet-iron, about five inches square, suspended vertically before the mouth of the speaker so as to vibrate freely by the motion of the air due to the speech, and suppose also another iron plate, of the like dimensions, similarly suspended before the ear of the hearer of the sound, and between these, but not in contact with them, is stretched the long telegraphic wire. Each end of this wire is attached to two coils of insulated wire surrounding a core of soft iron, the ends of which are placed near the middle of the plate, but not in contact with it. These four cores are kept in a magnetic condition by being attached at each end of the line to the two poles of a permanent magnet. Now it is evident that in this arrangement any disturbance of the magnetism of one of the permanent magnets, increasing or diminishing it, will induce electrical currents, which, traversing the long wire, will produce a similar disturbance of the magnetism of the arrangement at the other end of the wire. Such a disturbance will be produced by the vibration of the plate of soft iron due to the words of the speaker, and the current thus produced, changing the magnetism of the soft iron cores, will by reaction produce corresponding vibrations in the iron plate suspended before the ear of the hearer. The vibrations of the second plate being similar to those of the first will reproduce the same sounds. Audible speech has, in this way, been transmitted to a distance of three hundred miles, perfectly intelligible to those who have become accustomed to the peculiarities of certain of the sounds. All parts of a tune are transmittted with great distinctness and with magical effect.

"This telephone was exhibited in operation at the Centennial Exhibition, and was considered by the judges the greatest marvel hitherto

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achieved by the telegraph. The invention is yet in its infancy, and is susceptible of great improvements."

The other report was made by Sir William Thomson, and it is as follows. It is found in—

"Reports on Awards, Group XXV., Centennial Exhibition, pages 130, 131.

"3. ALEXANDER GRAHAM BELL, SALEM, MASS., U. S.

"GRAHAM BELL'S ELECTRIC TELEPHONE AND MULTIPLE TELEGRAPH.

"*Report*—The idea of an electric telephone, or apparatus for transmitting sounds to a distance by variations of electric current through a wire, has been for many years before the world, and has been realized in several ways, differing considerably in details as to the appliances at two points of the circuit for producing the variations of electric current and for deriving perceptible effects from them. An extension of this idea to some kind of electro-phonetic telegraphy was inevitable, even though no one had thought it might or could lead to practically useful results. But the idea of a multiple electro-phonetic telegraph transmitting simultaneously several different musical notes and using intermissions of these (like intermissions of currents in so many separate wires) for the simultaneous and independent transmission of different messages by one wire, is a very fine invention, of high scientific character, promising splendidly useful practical results.

"This invention is claimed by Mr. Graham Bell, and he is entitled to full credit for it, even though, as I believe is the case, it has been also independently invented by others, both in England and America.

"A very well worked-out realization of it is given in Mr. Bell's apparatus now exhibited. A great practical advantage of the electro-phonetic multiple telegraph over other methods of multiple telegraphy through one wire, is that no adjustment is required for varying conditions of the line to render the non-interference among the different messages perfect. Another even more important practical advantage is that it is indifferent between what points of the line and in which directions the different messages are being sent. The different messages can, in fact, be transmitted from any different points of the line, and each may be read at all other stations

(whether stations from which others of the messages are being sent or not) with practically perfect non-interference. Another important advantage is that earth currents and lightning discharges will never disturb the signalling.

"Mr. Graham Bell's apparatus includes an ingenious and effective instrument for automatically making and breaking an electric contact every time one of his telegraphic musical notes commences and ceases to sound. Thus his multiple telegraph may be made self-recording (after the Morse or Bain method), or may be worked forward by relay through greater lengths of line than imperfectness of the insulation allows to be worked in one circuit. Mr. Bell showed me in action two of these electro-phonetic relays, recording quite independently the transmission of independent messages by two musical notes in one wire. In addition to his electro-phonetic multiple telegraph, Mr. Graham Bell exhibits apparatus by which he has achieved a result of transcendant scientific interest,—the transmission of spoken words by electric currents through a telegraph wire. To obtain this result, or even to make a first step toward it,—the transmission of different qualities of sounds, such as the vowel sounds,—Mr. Bell perceived that he must produce a variation of strength of current in the telegraph wire as nearly as may be in exact proportion to the velocity of a particle of air moved by the sound; and he invented a method of doing so, a piece of iron attached to a membrane, and thus moved to and fro in the neighborhood of an electro-magnet, which has proved perfectly successful. The battery and wire of this electro-magnet are in circuit with the telegraph wire and the wire of another electro-magnet at the receiving station. This second electro-magnet has a solid bar of iron for core, which is connected at one end, by a thick disk of iron, to an iron tube surrounding the coil and bar. The free circular end of the tube constitutes one pole of the electro-magnet, and the adjacent free end of the bar-core, the other. A thin circular iron disk, held pressed against the end of the tube by the electro-magnetic attraction, and free to vibrate through a very small space without touching the central pole, constitutes the sounder by which the electric effect is reconverted into sound. With my ear pressed against this disk, I heard it speak distinctly several sentences, first of simple monosyl-

lables, 'To be or not to be' (marvellously distinct); afterwards sentences from a newspaper, 'S. S. Cox has arrived' (I failed to hear the 'S. S. Cox,' but the 'has arrived' I heard with perfect distinctness); then 'City of New York,' 'Senator Morton,' 'The Senate has passed a resolution to print one thousand extra copies,' 'The Americans of London have made arrangements to celebrate the Fourth of July.' I need scarcely say I was astonished and delighted; so were others, including some other judges of our Group, who witnessed the experiments and verified with their own ears the electric transmission of speech. This, perhaps the greatest marvel hitherto achieved by the electric telegraph, has been obtained by appliances of quite a homespun and rudimentary character. With somewhat more advanced plans, and more powerful apparatus, we may confidently expect that Mr. Bell will give us the means of making voice and spoken words audible through the electric wire to an ear hundreds of miles distant."

The judges were: Joseph Henry, Sir William Thomson, J. E. Hilgard, James C. Watson, H. K. Oliver, F. A. P. Barnard, J. Schudmayer, E. Lavasseur, P. F. Kupka, Ed. Favre-Perret, Chas. E. Emery.

This apparatus, and the transmission of speech by it, were noticed generally in the newspapers, and the invention attributed exclusively to Professor Bell. I instance the *Scientific American* of Sept. 9, 1876, the Boston *Transcript* of July 8, 1876, and the New York *Evening Post* of Sept. 5, 1876.

The Boston *Evening Transcript* of July 8, 1876, contains the following:—

*Notes at the Centennial.*—". . . Professor Bell has also a telegraphic and telephonic apparatus in this department for the transmission of many messages over a single wire, and of musical and articulate sounds by telegraph. The experiments which have been made in the presence of the Emperor of Brazil, Sir William Thomson, and others interested in the subject, have been highly interesting and satisfactory in their results."

The New York *Evening Post* of Sept. 5, 1876, contains the following:—

"Yet the telegraphic and telephonic apparatus invented by A. Graham

Bell should reconcile us to this loss. . . . Professor Bell has sent a valuable collection that well illustrates the mode by which many messages may be transmitted over a single wire, and also the ease with which musical and articulate sounds may be transmitted by telegraph. . . . Spoken words may be thus transmitted."

A set of these instruments was given to SIR WILLIAM THOMSON, and he is reported to have exhibited them, and explained them and the transmission of speech by them, on assuming the chair of the section of Physical Science at the Glasgow meeting of the British Association in August, 1876.

The Boston *Daily Advertiser* of Sept. 25, 1876, says:—

"The following passage, taken from the opening address of Professor Sir William Thomson, on assuming the chair of the section of physical science at the Glasgow meeting of the British Association, will be read with interest, as showing the impression made upon an English student of science, by our progress in discovery and in practical science: 'In the Canadian department, I heard, "To be or not to be," "There's the rub," through an electric telegraph wire; but scorning monosyllables, the electric articulation rose to higher flights, and gave me passages taken at random from the New York newspapers: "S. S. Cox has arrived" (I failed to make out the "S. S. Cox"), "The City of New York," "Senator Morton," "The Senate has resolved to print a thousand extra copies," "The Americans in London have resolved to celebrate the coming Fourth of July." All this my own ears heard, spoken to me with unmistakable distinctness by the thin circular disk armature of just such another little electro-magnet as this which I hold in my hand. The words were shouted with a clear and loud voice by my colleague judge, Professor Watson, at the far end of the line, holding his mouth close to a stretched membrane, such as you see before you here, carrying a little piece of soft iron, which was thus made to perform, in the neighborhood of an electro-magnet in circuit with the line, motions proportional to the sonorific motion of the air.

"'This, the greatest by far of all the marvels of the electric telegraph, is due to a young countryman of our own, Mr. Graham Bell, of Edinburgh and Montreal and Boston, now becoming a naturalized citizen of the United States. Who can but admire the hardihood of

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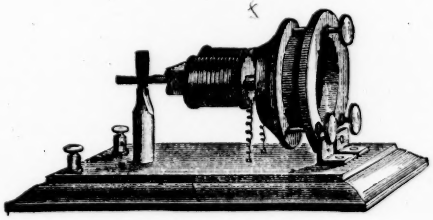
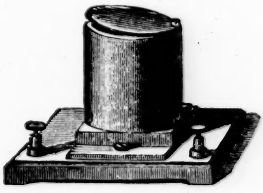
invention which devised such very slight means to realize the mathematical conception that, if electricity is to convery all the delicacies of quality which distinguish articulate speech, the strength of its current must vary continuously, and as nearly as may be in simple proportion to the velocity of a particle of air engaged in constituting the sounds?'"

This address, or portions of it, containing the foregoing in full or in substance, was published in various newspapers.

A description of the electric speaking telephone, with woodcuts of the apparatus given by Professor Bell to Sir William Thomson, and the foregoing extracts from Sir William Thomson's address to the British Association, were published in *Engineering* for Dec. 22, 1876, and reprinted in the *Scientific American* supplement, Feb. 10, 1877. These publications attributed the invention to Professor Bell exclusively. The drawings in *Engineering* are as follows:—





During the fall of 1876, and the following winter and spring, Mr Bell continued to experiment and operate publicly with his speaking telephone, and these exhibitions were noticed very generally in the newspapers as matters of practical value. I assisted in most or all of these. The invention was invariably attributed to Professor Bell alone.

The Boston *Daily Advertiser* of Oct. 14, 1876, says:—

"At a meeting of the American Academy on Wednesday evening, Professor Bell exhibited his wonderful discovery by which sounds may be transmitted through wires by means of the electric current. By the invention of peculiar apparatus, conversation may be carried on through hundreds of miles of wires with the greatest ease."

The *Scientific American* of Sept. 9, 1876, contained the following:—

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"THE HUMAN VOICE TRANSMITTED BY TELEGRAPH.

"Several weeks ago we gave a sketch and description of the thread telegraph, consisting of two small tin or wooden cylinders, each having a membrane stretched over one end, the two membranes connected by a stout thread. . . .

"Professor Graham Bell, by a device somewhat analogous, has succeeded in transmitting the tones of the human voice by telegraph. Instead of the thread, he connects the membranes of the two cylinders or drums with the armatures of the electro-magnets, one drum being placed at each end of the telegraph wire. In fact, he not long ago demonstrated the possibility of conveying vocal sounds by means of the ordinary telegraph wires and special appliances for transmitting and receiving the sounds. The apparatus used by Professor Bell is thus described: Two single-pole electro-magnets, each having a resistance of ten ohms, were arranged in circuit with a battery of five carbon elements, the total resistance being about twenty-five ohms. A drumhead of goldbeater's skin, about two and three fourths inches in diameter, was placed in front of each electro-magnet, and a circular piece of clock spring was glued to the middle of the membrane of each drumhead. One of these telephones was placed in the experimental room, and the other in the basement of an adjoining house. Upon singing into the telephone the sounds of the voice were reproduced by the instrument in the distant room; and if two persons sang simultaneously, the two notes were audible at the other telephone.

"At the time of the lecture, an experiment was made to show the transmission of articulate speech, an assistant going into the adjoining building, where one of the telephones was placed. Several familiar questions were, it is said, understood after a few repetitions. The vowel sounds alone are those faithfully reproduced. Diphthongal sounds and rotund vowels are readily distinguished, but consonants are generally unrecognizable. Now and then, however, a sentence comes out with almost startling distinctness, the consonants as well as the vowels being clearly audible. Professor Bell stated that telephonic effects can be produced with three varieties of currents,—the intermittent, the pulsatory and the undulatory. The first are characterized by the alternate presence and absence of electricity in the circuit, the pulsatory current by sudden changes in intensity, while undulatory currents are obtained by gradual changes

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analogous to the changes of density of air produced by vibrations of a pendulum.

"The most recent trial of Professor Bell's instrument was at his residence, Brantford, Canada, Aug. 11. The Toronto *Globe* states that instruments were placed, one in the porch of the residence, and the other in an outhouse on the grounds, and communication between these made by ten miles of wire. Musical notes, the human voice, and songs spoken and sung before one instrument were plainly audible by placing the instrument to the ear at the other. By this invention, too, any number of messages can be conveyed over one wire in either direction, provided they have a different pitch; the tones of the voice can pass over the electric wire, enabling the hearer at any distance to hear distinctly what is said, and to distinguish the voice of the speaker. On Aug. 10 the professor had communication made with his instrument on the common telegraph wire between Brantford and Mount Pleasant (five miles), and was spoken with, while in Mount Pleasant, by Professor D. C. Bell and Mr. Griffin, from the *Dominion* office, in Brantford. On the evening of Aug. 12 the professor tried a new experiment, having had an instrument made so that three persons could sing different tunes, or different parts of the same tune, into the instrument at the same time. The trial was perfectly successful, the different voices coming distinctly over the wire at the same time, so that they could be separately distinguished by the listener. The practical exemplification of the lately discovered system of telephony made by the professor afforded much pleasure and information to those present."

The Boston *Daily Advertiser* of Oct. 19, 1876, contained the following:—

## TELEPHONY.

### Audible Speech Conveyed Two Miles by Telegraph.

*Professor A. Graham Bell's Discovery.—Successful and Interesting Experiments.—The Record of a Conversation carried on Between Boston and Cambridgeport.*

The following account of an experiment made on the evening of Oct. 9 [1876], by Alexander Graham Bell and Thomas A. Watson, is interesting, as being the record of the first conversation ever car-

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"At the time of the lecture, an experiment was made to show the transmission of articulate speech, an assistant going into the adjoining building, where one of the telephones was placed. Several familiar questions were, it is said, understood after a few repetitions. The vowel sounds alone are those faithfully reproduced. Diphthongal sounds and rotund vowels are readily distinguished, but consonants are generally unrecognizable. Now and then, however, a sentence comes out with almost startling distinctness, the consonants as well as the vowels being clearly audible. Professor Bell stated that telephonic effects can be produced with three varieties of currents,—the intermittent, the pulsatory and the undulatory. The first are characterized by the alternate presence and absence of electricity in the circuit, the pulsatory current by sudden changes in intensity, while undulatory currents are obtained by gradual changes

analogous to the changes of density of air produced by vibrations of a pendulum.

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The following account of an experiment made on the evening of Oct. 9 [1876], by Alexander Graham Bell and Thomas A. Watson, is interesting, as being the record of the first conversation ever car-

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ried on by word of mouth over a telegraph wire. Telephones were placed at either end of a telegraph line owned by the Walworth Manufacturing Company, extending from their office in Boston to their factory in Cambridgeport, a distance of about two miles. The company's battery, consisting of nine Daniell cells, was removed from the circuit, and another, of ten carbon elements, substituted. Articulate conversation then took place through the wire. The sounds, at first faint and indistinct, became suddenly quite loud and intelligible. Mr. Bell, in Boston, and Mr. Watson, in Cambridge, then took notes of what was said and heard, and the comparison of the two records is most interesting, as showing the accuracy of the electrical transmission:

*Boston Record.*

MR. BELL. What do you think was the matter with the instruments?

MR. WATSON. There was nothing the matter with them.

B. I think we were both speaking at the same time.

W. Can you understand anything I say?

B. Yes; I understand everything you say.

W. The reason why you did not hear at first was because there was a relay in the circuit.

B. You may be right, but I found the magnet of my telephone touching the membrane.

W. I cut this relay out, and then the sounds came perfectly.

B. I hear every syllable. Try something in an ordinary conversational voice.

W. Shall I connect their battery in the circuit?

B. No; there is no necessity to connect their battery in the circuit, for the sounds come out quite loudly.

W. I am now talking in quite a low tone of voice.

B. The sounds are quite as loud as before, and twice as distinct.

W. Cut out the battery and then talk.

B. All right; I will cut out the battery now if you will keep listening.

*Cambridge Record.*

MR. BELL. What do you think is the matter with the instruments?

MR. WATSON. There is nothing the matter with them.

B. I think . . . at the same time.

W. Can you understand anything I say?

B. Yes; I understand everything you say.

W. The reason why it did not work at first was because there was a relay in the circuit.

B. You may be right, but I find . . . that my . . . touches the membrane.

W. I cut the relay out, and then the sounds came perfectly.

B. I hear every syllable. Try something in a conversational voice.

W. Shall I connect their battery in the circuit?

B. No; there is no necessity for putting their battery in the circuit, as the sounds come out quite loudly.

W. I am now talking in quite a low tone of voice.

B. The sounds are quite as loud as before, and quite as distinct.

W. Cut out the battery and then talk.

B. All right; I will cut out the battery now if you will keep listening.

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[Here an interruption occurred, and after a short time Mr. Bell said:]

B. I thought you were going to say something.
W. Is the battery cut out?
B. No; but I will do it now.

B. I thought you were going to say something.
W. Is the battery cut out.
B. No; but I will do it now.

[Battery having been cut out, Mr. Bell continued:]

B. Do you year anything now?

[Battery replaced.]

B. Did you hear anything?
W. No; not a sound.
B. Say something to me when I cut out the battery again.

B. Did you hear anything?
W. No; not a sound.
B. Say something to me when I cut out the battery again.

[Battery cut out.]

W. . . . . .

W. I could not hear a sound when the battery was cut out.

[Battery replaced.]

B. I fancy I heard a trace of your voice.
W. Shall I put on our battery, to see if it increases the effect?
B. I'll tell you what we'll do. We'll take off our battery, and put on theirs, as before.

B. I fancy I heard a trace of your voice.
W. Shall I put on their battery, to see if it increases the effect?
B. I'll tell you what we'll do. We'll take off our battery altogether, and put on theirs, as before.

[The company's batteries having been placed in circuit, faint and indistinct sounds were heard at the Boston end, and then came the intelligible sentence.]

W. Is our battery off?
B. Yes, our battery is off. What have you been doing? The sounds were quite soft at first, but now they are quite loud.
B. Shall I put in our battery again?
W. (Indistinctly heard.) That was very indistinct. Put on our battery.

W. Is our battery off?
B. (Very indistinct — unintelligible.)

W. That was very indistinct. Put on our battery.

[Original battery replaced.]

B. We may congratulate ourselves upon a great success.
W. Both batteries are on now. (Another sentence heard indistinctly.)

B. We may congratulate ourselves on our great success.
W. We deserve success. Both batteries are on now.

B. Repeat the last sentence.

W. Both batteries are on now.

B. I understood that before, but thought you said something else.

W. Remove their battery, please.

B. All right; our battery is the only one on now.

W. I have put battery cells on here.

B. How many cells have you there?

W. S-i-x—six.

B. Please whisper something to me.

W. Sound of the whisper clearly audible, but the utterances unintelligible.

B. I could hear you whispering, but could not understand what you said.

W. Perhaps we have got the batteries opposed to one another. Had you not better reverse your battery and see what the matter is, or rather what the effect is?

B. I will try the effect of reversing my battery.

B. Repeat the last sentence.

W. Both batteries are on now.

B. I understood that before, but thought you said something else.

W. Reverse your battery, please.

B. All right; our battery is the only one on now.

W. I have six Daniell cells on here.

B. How many cells have you on there?

W. S-i-x—six.

B. Please whisper something to me.

W. Now I am whispering.

B. I could hear you whispering, but could not understand what you said.

W. Perhaps we have got the batteries opposed to one another. Had you not better reverse yours and see what the effect is?

B. I will try the effect of reversing my battery.

[Battery reversed.]

B. Is this any better?

W. That sentence was accompanied by that curious crackling sound.

B. Yes; I hear it too.

B. What time is it by your watch?

B. Is this any better?

W. Much fainter, accompanied by that curious bubbling sound.

. . . . . .

. . . . . .

. . . . . .

[Battery again reversed.]

W. What are you doing? I have not heard anything except . . . for quite a while.

B. I asked you what time it was by your watch. Perhaps you hear me better now, because I have reversed the battery again.

W. My battery is now cut out.

B. Don't you think we better go home now?

W. Yes; but why does your talking come out so much fainter now?

W. What are you doing? I haven't heard anything except that bubbling sound for quite a while.

B. I asked you . . . . . .

. . . . . .

. . . . . because I . . .

. . . . . .

W. My battery is now cut out.

B. Do you think we had better go home now?

W. Yes; but why does your talking come out so much fainter now?

[Mr. Bell here placed the magnet of the telephone nearer to the membrane.]

B. Because I had moved the magnet further away from the membrane.

W. That was very much more distinct.

B. Will you try to understand a long sentence if I speak right on?

W. I will.

B. A few minutes ago I heard a fire engine pass by the door. I don't know where the fire is, but the number of the box is 196.

W. The time by my watch is five minutes past ten. Had I not better go into Boston?

B. Yes; I think it is time to stop now.

W. Shall I go to Exeter Place?

B. Yes; but look in here on your way, in case I have not gone.

W. Let us talk conversationally, without noting

B. Because I moved the magnet further away from the membrane.

W. That was very much more distinct.

B. Will you try to understand a longer sentence if I speak right on?

W. I will.

B. A few minutes ago I heard a fire engine go past the door. I don't know where the fire is, but the number of the box is 196.

W. The time by my watch is five minutes past ten. Had I not better go into Boston?

B. Yes; I think it is time to stop now.

W. Shall I go to Exeter Place?

B. Yes; but look in here on your way, in case I have not gone.

W. Let us talk conversationally, without noting.

Conversation was then carried on for about half an hour with the utmost freedom, and the experiment closed.

*Int.* 9. Before going any further, please to state whether the preceding account in the *Advertiser*, of your use of the telephone between Boston and Cambridge, is substantially correct, so far as it goes.

*Ans.* It is correct.

*Int.* 10. Please to continue your answer to Int. 8.

*Ans.* The Boston *Evening Transcript* of Oct. 19, 1876, says:—

"*Telephony.* . . . The registry of sounds by telegraph has now been carried to such a point that the delicate variations involved in the articulation of human speech are transmitted with such unerring accuracy and distinctness that one may talk with another through the telegraph as though face to face.

"The leading scientific men of the world gathered at Philadelphia last summer saw the fact accomplished on a small experimental scale. Sir W. Thomson was so impressed that in his opening

address as president of the British Association he described it at some length, and pronounced it the greatest by far of all the marvels of the electric telegraph. Ten days ago the test was repeated over an actual out-of-door telegraph between this city and Cambridge. The entire success of this experiment marks, for all that we can see, a revolution and advance in the world's progress worthy to rank with the practical completion of the first printing telegraph in New York City about forty years ago, and with the laying of the great ocean cables twenty years ago.

"The operation of this new and startling development of telegraphic mechanism is thus described by Professor Thomson, in the address referred to:—

"'All this my own ear heard spoken to me with unmistakable distinctness by the thin, circular disk armature of just such another little electro-magnet as this which I hold in my hand. The words were shouted with a clear and loud voice by my colleague judge, Professor Watson, at the far end of the line, holding his mouth close to a stretched membrane, such as you see before you here, carrying a little piece of soft iron, which was thus made to perform, in the neighborhood of an electro-magnet in circuit with the line, motions proportional to the sonorific motions of the air.' . . .

"We give in another column the interesting account of the practical exemplification of the invention between Boston and Cambridge. The inventor, Mr. Graham Bell, is a young Edinburgh scientist, formerly of Montreal, but later of this city, and a naturalized citizen of the United States."

During the fall of 1876 and the following winter and spring, Mr. Bell operated publicly his electric speaking telephone. I assisted at most or all of these exhibitions. They were noticed very generally in the newspapers as matters of practical value. I mention:—

Boston *Post*, Oct. 20, 1876.

Boston *Daily Evening Traveller*, Oct. 19, 1876.

Boston *Sunday Herald*, Oct. 22, 1876.

Titusville *Herald*, Oct. 22, 1876.

Boston *Evening Transcript*, Oct. 19, 1876.

These describe the transmission of speech from Boston to Cambridge.

The New York *Tribune* of Monday, Oct. 23, 1876, says:—

"The experiments which Professor A. Graham Bell has been recently making, relative to the transmission of speech by wire, have been quite successful. Two operators were stationed two miles apart, one in Boston and the other in Cambridge. The battery ordinarily used was replaced by one of ten carbon elements. At first the sounds were indistinct, but soon they grew clear and intelligible. The operators carried on a long conversation, and on subsequently comparing their records ascertained that the tones had been transmitted with perfect accuracy."

An editorial in the New York *Tribune* of Nov. 9, 1876, contained the following:—

"The Centennial Exhibition has afforded the opportunity to bring into public view many inventions and improvements which otherwise would only have been known to the smaller circles that may find them of service. . . . The telephone is a new instrument of electrical science, more likely than some of the rest to find immediate use. It operates by transmitting the current through a tuning-fork. The fork will only vibrate a given number of times in a second. A message can be sent through it by the usual Morse code, there being no apparent interference between the tuning-fork vibrations and the message. But at the other end of the line the message can be taken off through a tuning-fork in unison with the first. Consequently, if a tuning-fork of different pitch is interposed at each of several stations served by one wire, and the messages are sent through forks of corresponding pitch from the head office, the message to one station will not be repeated at the others during transmission.

"Sir William Thomson, at the Glasgow meeting of the British Association for the Advancement of Science, gave foreign notoriety to another of the Centennial exhibits that has attracted great attention from the judges of the group to which it belongs. It is a curious device, that might fairly find place in the magic of Arabian tales. A membrane is stretched over the end of a short speaking trumpet. The membrane carries a small piece of metal which is, so to speak, the armature of a magnet. The magnet forms part of a telegraph circuit, through which

a current is passing. To send a message it is only needful to talk loudly into the trumpet.

"The message is received by a similar trumpet with membrane and armature at the other end of the line; and that trumpet being placed to the ear repeats the sound like an echo. Don Pedro was with the scientific people who tested this instrument on one occasion; so accurately did it reproduce sounds that each member of the party was in turn recognized by peculiarities in voice or accent. The final test was the reading of a paragraph from the news columns of the *Tribune*. Of what use is such an invention? Well, there may be occasions of state when it is necessary for officials who are far apart to talk with each other without the interference of an operator. Or some lover may wish to pop the question directly into the ear of a lady and hear for himself her reply, though miles away; it is not for us to guess how courtships will be carried on in the twentieth century. It is said that the human voice has been conveyed by this contrivance over a circuit of sixty miles. Music can be readily transmitted. Think of serenading by telegraph!"

Nov. 26, 1876. We carried on a long conversation on the lines of the Eastern Railroad, using part of the time a circuit from Boston to Salem (15 miles), and part of the time a circuit from Boston to North Conway and back to Salem, and part of the circuit from Boston to Portland and back, about two hundred miles of actual telegraph wire.

This is noticed in—

Boston *Post*, Boston *Daily Globe*, Boston *Daily Advertiser*, and Boston *Herald*, of Nov. 27, 1876.

The Boston *Post* of Nov. 27, 1876, says: "The experiments in electric telephony which Prof. A. Graham Bell has been conducting for several years past have resulted in the development of apparatus by means of which the human voice, as ordinarily used in speaking, can be transmitted with certainty and ease to an indefinite distance—assuredly hundreds of miles. . . .

"The latest experiments with the telephones were made yesterday over the wires of the Eastern Railroad, that day being selected because the trials would not then be interrupted by the ordinary business of the line. Professor Bell, President Rockwell, of the Eastern

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Road, and wife, Miss Stearns, Mr. Morrisson, and Mr. Hubbard, besides two telegraph operators, were the occupants of the Boston office. The instruments were arranged for about a twenty-mile test, consequently, Salem, about sixteen miles away, was the point at which the second telephone was fixed. Mr. Thomas A. Watson, assisted by the Salem operator, was in charge there. All those at the Boston end of the line held free and easy conversation with the Salem office, even a whisper or a loud breath being distinctly heard at one end when given at the other."

*Int.* 11. Please to answer the same interrogatory as to the first half of 1877.

*Ans.* Jan. 13, 1877, Professor Bell gave a lecture on his electric speaking telephone, with an exhibition of it, before the Washington Philosophical Society, at Washington, D. C. This was reported in the Washington *Evening Star* of Jan. 20, 1877.

The said report in the *Evening Star* begins as follows:—

"*Bell's Telephone.* At a meeting of the Washington Philosophical Society on the evening of the 13th January, Mr. Bell, the inventor, gave to the members a description of the construction and operation of his most admirable and wonderful invention, *and exhibited it in operation.*"

The Boston *Daily Advertiser* of Jan. 22, 1877, contained the following:—

"The most important of the tests made recently by Professor A. Graham Bell, in the practical development of telephony, is dispensing with the use of the battery entirely, so that now all that is required to communicate between the most distant places is simply a line of wire and the telephones.

"Yesterday morning successful experiments were made between Boston and Salem, on the Eastern R. R. wire. At the Boston end were Professor Bell, Mr. Nutting, the operator, Mr. E. H. Foster, Mr. William Auld, and Mr. J. B. Parker; and at the Salem end, Mr. T. A. Watson, who is associated with Mr. Bell, and the lady operator.

"Recently two Japanese gentlemen conversed in their own language through the telephones, and had no difficulty in understanding all that they said. An experiment has been made in overcoming an

artificial resistance greater than the Atlantic cable, and there is no doubt but that it will be possible to talk across the Atlantic."

The Boston *Evening Transcript*, of Feb. 1, 1877, contained a long description of an exhibition of a telephone, in which the following is found:—

"At noon, yesterday, a distinguished party of gentlemen were assembled at the office of the Boston Rubber Shoe Company, on Congress Street, in order to witness a series of experiments performed on the telephone between the inventor, Professor A. Graham Bell, here, and his associate, Mr. Thomas A. Watson, at the residence of Mr. Converse, at Malden, about six miles distant.

"Professor Bell had been invited by some of our most prominent citizens to give a practical demonstration of the most recent developments of an invention which, in accordance with its name, has already sounded far and wide the fame of the telephone. The experiments yesterday were as follows:—

"Telephones having been connected with the private telegraphic line of the Boston Rubber Shoe Company, and the operators at either end having taken up their station, conversation was at once commenced. Stationed at the Boston end of the wire, Professor Bell, requested Mr. Watson to speak in loud tones, with a view of enabling the entire company at once to distinguish the sounds.

"This was so successful that a smile of mingled pleasure and surprise played on the features of those present. That it, however, might not be supposed that loud speaking was essential to intelligibility, Mr. Bell explained that soft tones could be heard across the wires even more distinctly than loud utterances, even a whisper being audible. In confirmation of this statement, Mr. Watson commenced speaking in turn to each member of the company, and after the efficiency of this method had been proved to the satisfaction of all, he took up a newspaper and informed the assemblage that gold had closed the previous evening at New York at 105⅛.

"As there were quite a number of business men present, the effect that this practical demonstration of the value of the telephone produced can scarcely be exaggerated. Other passages from the daily journals were then given, and by this time the desire for conversation having become general, Mr. Watson was plied with questions,

such as, Is it thawing or freezing at Malden? Who is to be the next President? etc., etc. It was remarkable that Mr. Watson was able to distinguish between the voices at the Boston end, he calling at least one gentleman by name as soon as the latter commenced speaking.

"This went on for some time until a lady at the Malden end sent the company an invitation to lunch per telephone, and an appropriate response was made by the same medium.

"At length the company was requested to remain quiet while a lady at the other end conveyed to them the sweet strains of music. The assemblage thereupon listened with rapt attention while a young lady commenced singing 'The Last Rose of Summer.' The effect was simply charming. Possessing, as the fair cantatrice does, a voice of exquisite sweetness, the sounds penetrated into the Boston end of the telephone with a distinctness equal to that attainable in the more distant parts of a large concert room, and a unanimous vote of thanks was sent by the handy little instrument which had procured for the assemblage so agreeable an hour.

"Among those present were electricians and gentlemen occupying prominent positions on our Western railroads, and one and all expressed the conviction that the telephone was destined to achieve the greatest possible results. Let us hope that the day is fast approaching when every man will be in a position to turn on the electricity in his house with the same facility with which he now turns on the water or the gas.

C. H. H."

Early in 1877, Professor Bell began to give public lectures and exhibitions of his electric speaking telephone.

He gave one in Salem, Mass., Feb. 12, 1877, and a report of it, published in the Boston *Globe* of Feb. 13, was transmitted from Salem to Boston by his speaking telephone.

The said *Globe* of Feb. 13, 1877, contained the following:—

"We have the pleasure of presenting to our readers this morning the first despatch ever sent to a newspaper by the newly invented telephone, Professor A. Graham Bell's system of transmitting sound by telegraph. The despatch was sent from Salem, where Professor Bell lectured last evening, our active representative in that city hav-

ing secured the exclusive privilege of the instrument for that purpose. The message was received in this city by another representative of the *Globe*, who could readily recognize the voice at the other end.

. . . . . .

'SENT BY TELEPHONE.—THE FIRST NEWSPAPER DESPATCH SENT BY A HUMAN VOICE OVER THE WIRES.—TO THE DAILY GLOBE FROM SALEM.—PROFESSOR GRAHAM BELL EXPLAINS HIS VALUABLE INVENTION.—AN ENTHUSIASTIC AUDIENCE.—HOW THE CAPACITY OF THE TELEPHONE WAS TESTED.

"*Special despatch by telephone to the Boston Globe.*

"SALEM, Feb. 12, 10.55 P. M.—Professor A. Graham Bell, the inventor of that wonderful instrument, the telephone, which has caused so much interest in the scientific world, and which is now becoming so popularly known, lectured on his invention at Lyceum Hall this evening. The lecture was one of a course of the Essex Institute, and about five hundred persons were present.

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"Mr. Watson was then asked to make a speech to the audience. He expressed himself as having more confidence eighteen miles away than if he were present. His speech was as follows:—

"'*Ladies and Gentlemen*,—It gives me great pleasure to be able to address you this evening, although I am in Boston and you in Salem.' This could be heard thirty-five feet distant,—that is, all over the hall,—and brought down the house with applause. A system of questioning was then carried on, and Mr. Watson was asked if he heard the applause. The answer was, 'I was not listening; try again.' The applause was given, and its receipt at once acknowledged in Boston. Coughing and singing were then heard, and a variety of questions were then asked from the Salem end, and among them, 'What news from the Electoral Commission?' followed by the distinct answer of 'I don't know of any.' But the news came fleeting along that the engineers of the Boston and Maine Railroad had struck. Gen. Cogswell asked if trains were running; the answer was clear and distinct that they were not at 5.30 o'clock.

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Professor Bell introduced the Rev. E. C. Bolles, who said, 'I shake hands with you cordially in imagination twenty miles away.' The Rev. E. S. Atwood asked, 'Does it rain?' 'It does not in Boston,' was Mr. Watson's answer. Professor Gage, the electrician, then spoke through the telephone, endeavoring to have his voice recognized. This could not be done, as Mr. Watson was not familiar with the voice. Mr. Shaje Zsawa was recognized, Mr. Watson being perfectly familiar with his tones. One of the assistants in Boston then said that 'Hold the Fort' would be sung in Boston, and the tune which followed was readily recognized. Professor Bell closed his lecture by briefly stating the practical uses to which he was confident the telephone could be applied. Hearty applause was afforded the lecturer as he finished, and people flocked about the stage in large numbers to more closely examine the wonderful instrument that had placed them in audible communication with people nearly twenty miles away.

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"This special by telephone to the *Globe* has been transmitted in the presence of about twenty, who have thus been witnesses to a feat never before attempted; that is the sending of a newspaper despatch over the space of eighteen miles by the human voice; and all this wonder being accomplished in a time not much longer than would be consumed in an ordinary conversation between two people in the same room.

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"THE SCENE AT THE BOSTON END.

"The instrument which transmitted the wonderful voice message to the listening ears in this city was placed in a little room in Exeter Place, where were assembled Professor Watson, Benjamin Bridden, the electrician, Professor E. B. Warman, and Mr. A. B. Fletcher, representative of the *Globe*. The experiment was certainly a great success. The conversation with the friends eighteen miles away was carried on in ordinary tones of voice. The *Globe* representative in Boston very easily recognized the voice of the transmitter of the despatch in Salem; and very distinctly heard the applause which was given in the Essex Institute Hall. It was a very

noteworthy occasion, certainly; and the complete success attained led to the discussion of many plans for the further practical utilization of the telephone, which sends its first newspaper despatch to the *Globe* readers for their delectation and wonder, this morning."

The Boston *Daily Globe* of Feb. 15, 1877, contained the following:—

"THE TELEPHONE.—SOMETHING ABOUT THE CONSTRUCTION AND WORKING OF PROFESSOR BELL'S WONDERFUL INVENTION.

"As the telephone, the new invention of Professor A. Graham Bell, is but little understood, the following reprint of a description and explanation of the instrument may not be amiss:—

"'The telephone in its present form consists of a powerful, compound, permanent magnet, to the poles of which are attached ordinary telegraph coils of insulated wire. In front of the poles, surrounded by these coils of wire, is placed a diaphragm of iron. A mouthpiece to converge the sound upon this diaphragm substantially completes the arrangement. The motion of steel or iron in front of the poles of a magnet creates a current of electricity in coils surrounding the poles of the magnet, and the duration of this current of electricity coincides with the duration of the motion of the steel or iron moved or vibrated in the proximity of the magnet. When the human voice causes the diaphragm to vibrate, electrical undulations are induced in the coils environing the magnets precisely analogous to the undulations of the air produced by that voice. These coils are connected with the line wire, which may be of any length, provided the insulation be good. The undulations which are induced in these coils travel through the line wire, and passing through the coils of an instrument of precisely similar construction at the distant station, are again resolved into air undulations by the diaphragm of this instrument.'

"It was by this wonderfully simple instrument that the three quarter of a column report of Professor Bell's lecture was transmitted from Salem to the GLOBE by the voice on Monday evening. All who saw the working of the instrument were astounded at the results obtained."

The following report of the Salem lecture appeared in the Salem *Observer* of Feb. 17, 1877:—

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"SATURDAY, Feb. 17, 1877.

"THE TELEPHONE.—The illustrated lecture upon telephony, by Professor A. Graham Bell, was exceedingly interesting. The results exhibited were indeed amazing; nearly every experiment was successful. . . .

"On Monday evening Mr. Watson, who was in the Boston office, 'wired' several tests to the audience of five hundred who were assembled in the Lyceum Hall. He conversed with Professor Bell freely; the latter asking questions in an ordinary tone of voice, with distinct articulation, and the answers immediately returning and having a sort of muffled sound. Mr. Watson addressed some words to the audience in Salem, which were distinctly heard, and the applause which followed was heard by him in Boston. He sang 'Auld Lang Syne' and other pieces, and played upon a reed organ, all the sounds of which were duly delivered at the Salem end of the wire. The person in Boston was also heard to cough and to laugh. During the evening Rev. Dr. Bolles, Rev. Mr. Atwood, Professor Gage, General Cogswell, a gentleman from Japan, and a lady (Miss Loring), all spoke successfully through the telephone. A full report of the meeting was sent to the *Globe* by telephone from its correspondent, Mr. Bachelder.

"The apparatus by which this astonishing result is secured is wonderfully simple; only a telegraphic wire, a horseshoe magnet, two helices and a vibrating disk, at each end. The audience see only a mahogany box upon the table, of the appearance of an ordinary photographer's camera. The tube in the end is used in this case to speak into and hear out of. Within the box is a horseshoe magnet. Opposite each arm of the magnet is a helix of the usual construction.

"One end of the wire among the helices is connected with the ground, and the other with Boston, or the place in operating connection. Set up against the helices, within a sixteenth of an inch, is a sheet of thin polished iron, upon which the voice of the operator impinges when speaking. The magnet induces an electrical current in the telegraphic wire. The vibrating disk imparts pulsations to this electrical current corresponding to the sounds, which are conveyed to Bos-

ton, and reproduce themselves upon the vibrating disk there with exactness of tone and articulation. The little four inches of iron utters the whole gamut of the human voice. This is indeed wonderful,—the greatest achievement of modern science. Another exhibition of the telephone is to be given."

The following is an extract from an article in the New York *Sun* of Feb. 20, 1877:—

"PROF. BELL'S TELEPHONE.—THE HUMAN VOICE CARRIED A HUNDRED AND FORTY MILES.—MARVELLOUS STORIES ABOUT THE LATEST ACHIEVEMENT OF SCIENCE.—MUSIC IN SALEM AND APPLAUSE IN BOSTON.—THE CONSTRUCTION AND CAPABILITIES OF THE INSTRUMENT DESCRIBED.

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"The honor of having received the first newspaper despatch ever sent by means of the telephone belongs to the Boston *Globe*. A report of a lecture by Professor Bell, in Salem, was transmitted verbally to it last Monday night. This lecture was about the telephone, and in the course of the evening a series of remarkable experiments was made in the presence of the audience. Songs and brief speeches were sent from Boston, and the applause which greeted their reception in Salem was distinctly heard in Boston. Imagine sitting in a hall and hearing a man, eighteen miles away, sing 'Hold the Fort.'

"'I haven't the slightest doubt,' Mr. Watson said to-day, 'that in a few months things will be so that a man can make a lecture here in Boston and be heard by an audience in any part of the country.'

"'Do you expect that the telephone will entirely supersede the present system of telegraphing?' I asked.

"'Yes, we expect it will, eventually. A company is now forming for the purpose of manufacturing and introducing the instrument. In time it can't fail to replace the old dot and line alphabet system entirely. We expect, at first, it will be used mostly on private lines and for city business. It will probably take the place of the present district telegraph companies and the like, as it will be especially convenient for that class of business.'

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"The wonderful little instrument, of whose future value to civiliza-

tion the inventor is so sanguine, consists of a powerful compound permanent magnet, to the poles of which are attached ordinary telegraph coils of insulated wire. In front of the poles, surrounded by these coils of wire, is a diaphragm of iron. A mouthpiece, whose function is to converge the sound upon this diaphragm, substantially completes the arrangement. The operation of the instrument is thus described by Professor Bell: The motion of steel or iron in front of the poles of a magnet creates a current of electricity in coils surrounding the poles of the magnet, and the duration of this current of electricity coincides with the duration of the motion of the steel or iron moved or vibrated in the proximity of the magnet. When the human voice causes the diaphragm to vibrate, electrical undulations are induced in the coils around the magnet precisely similar to the undulations of the air produced by the voice. The coils are connected with the line wire, and the undulations induced in them travel through the wire, and passing through the coils of another instrument of similar construction at the other end of the line, are again resolved into air undulations by the diaphragm of this instrument. The voltaic battery is entirely dispensed with. The line wire may be of any given length, provided the insulation be good. Professor Bell further says that soft tones can be heard across the wires even more distinctly than loud utterances, even a whisper being audible."

Feb. 23, 1877, a second lecture and public exhibition was given at Salem. A long report of this was transmitted by telephone, and published in the Boston *Daily Globe* of Feb. 24, 1877. That report contains the following:—

"*Special Despatch by Telephone to the* BOSTON GLOBE.

"SALEM, Friday, Feb. 23, 10.20 P. M.—Lyceum Hall has been crowded this evening with an audience of five hundred, which had assembled to hear Professor A. Graham Bell's interesting lecture on his wonderful invention, the telephone, and the results obtained by the evening's exhibition were certainly most astonishing. This was the second public exhibition of the new invention and its practical uses, and Salem has been fortunate indeed in having both given before her citizens. This second lecture and exhibition was given in

response to an invitation to Professor Bell by a number of scientific gentlemen and prominent citizens, and the audience was one which only a rare and notable occasion can draw together in Salem. Among the more prominent people in the audience were the Hon. George B. Loring, Judge Endicott, of the Supreme Court, Professor D. D. Hagar, of the State Normal School, Dr. J. R. Nichols, of Haverhill, editor of the Boston *Journal of Chemistry*, Judge Osgood, Mayor Oliver, Aldermen Daton and Stone, Professor John Robinson, Ex-Mayor Williams, Dr. Henry Wheatland, President of the Essex Institute, the Rev. Messrs. Arey, Dean, and Atwood, John W. Perkins, master of the Salem High School, General William Cogswell, J. S. Packard, Esq., and many other prominent citizens. The experiments were similar to those given at the former lecture, and were eminently successful, receiving hearty applause. Professor Thomas A. Watson, Professor Bell's assistant, transmitted several messages from the Boston end of the telephonic wire.

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"The company at the Boston end of the telephonic wire between Boston and Salem was quite as numerous as Professor Bell's laboratory could well accommodate. It is a little room at the end of Exeter Place, up three flights of stairs, with the various instruments of the telephonic apparatus to be seen on every hand. On one of the tables were the models on which Professor Bell worked out the telephone as it now exists; and they form an interesting study. Books, letters and papers, all pertaining in more or less degree to the science of electricity, are arranged about the room, which is plainly and tastefully furnished. Occupying the post of duty near the working instrument was Professor Thomas A. Watson, Mr. B. F. Bridden having charge of the working of the electric apparatus, with two young lads as assistants. The company present included Mr. D. P. Richards, who has been one of Professor Bell's co-workers, the Hon. Charles Levi Woodbury, John C. Hoadley, of Lawrence, Dr. Henry, I. Bowditch, Dr. C. J. Blake, Mr. W. A. Hovey, and Mr. C. E. Hurd, of the *Transcript*, three gentlemen from one of Dr. Tourjée's Tabernacle choirs, a cornet player, and an artist who was illustrating the scene for the *Scientific American*, besides reporters from the various city papers.

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"THE GLOBE despatch then came, followed by another press message, giving merely the news furnished by THE GLOBE about the telephone a week ago. Then 'Yankee Doodle' and 'Auld Lang Syne' were sung by Professor Bell, and distinctly heard in every tone by all in the room; and at 10.30 the conference came to an end."

The Providence *Press* of Feb. 24, 1877, had a long account of the Salem lecture, which contained the following:—

THE PROVIDENCE PRESS.

Feb. 24, 1877.

"We willingly surrender space to-day to the somewhat enthusiastic report by a member of our editorial staff who was invited to witness the experiments with the telephone last night at Salem. The importance of the invention promises to be such as to make all obtainable knowledge of it valuable, and we do not remember to have yet seen any so detailed and intelligible description of its workings as our representative furnishes.

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"HOW THE THING IS DONE,

is, of course, the practical reader's demand. It is done by a magnificent effort of genius, making itself felt with common tools. It is simplicity embodied and almost made personal. There is not even a battery to send an electric current along the line, for the affair is sufficient unto itself within its six by twelve inch dimensions, asking nothing of existing telegraphy but the wires it has strung. The principle is the familiar one that a plate of iron presented to a coil of insulated wire on the end of a magnet causes an electric current to traverse the magnet, provided the circuit is complete. Professor Bell, therefore, takes a horseshoe magnet, places on each of its ends a nearly flat spiral wire, and just in front of the points of the spirals, an infinitesimal distance away, sets up his plate of iron. To complete this circuit, he connects one arm of the magnet with the earth, by means of the gas pipes, and the other communicating wire runs out from the other arm to wherever the other operator may be stationed, with a similar earth connection on the magnet at his end." . . .

On the occasion of this Salem lecture I was at the Boston end of the telephone line, and the account given in the papers which I have quoted from is substantially correct, so far as came under my knowledge. I made the instruments used, and they are correctly described.

The lecture at Salem was followed by a series of lectures in Boston, Providence, Lowell, Manchester and New York, and these were extensively noticed in newspapers in different parts of the country: *e. g.*, the New York *Sun*, Feb. 11, 1877, had nearly a column about the lecture at Salem; the Boston *Journal of Chemistry*, March 1, 1877, had a long account; also the New York *Times; Daily Graphic* of March 6, 1877, with illustrations; *Scientific American*, March 31, 1877, with illustrations; *Frank Leslie's*, March 31, 1877, with illustrations; *The Athenæum*, London, England, March 3, 1877. At all of them electric speaking telephones with metallic diaphragms were used; at all of them the electric speaking telephones were publicly exhibited, their construction and operation explained, and they were publicly used in the transmission of articulate speech. At these exhibitions an admission fee was charged and paid by the audience.

The following accounts of them are substantially correct, so far as they came within my knowledge. The instruments used were made by me, or under my supervision.

The following is the opening paragraph of the article in the Boston *Journal of Chemistry*, of March 1, 1877, above referred to:—

BOSTON JOURNAL OF CHEMISTRY.

BOSTON, MARCH 1, 1877.

"THE TELEPHONE.

"The telephone is the invention of Professor A. Graham Bell, of this city, and has resulted from a course of inductive reasoning, growing out of careful study of the philosophy of sound, as related to wave motions in air, and in metals when induced by electrical excitation. The instrument is exceedingly simple and inexpensive, and easily understood. It consists in attaching to the terminals of the ordinary telegraph wires, between any two points, powerful compound magnets, with coils of wire connected. In front of the pole, surrounded by these coils of wire, is placed a diaphragm of iron. A

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mouthpiece to converge the sound upon the diaphragm, substantially completes the arrangement. When the human voice causes the diaphragm to vibrate, closing and breaking the circuit with each vibration, electrical undulations are induced in the coils, precisely analogous to the undulations of the air produced by that voice. These coils are connected with the line wire, which may be of any length, provided the insulation be good. The undulations induced in these coils travel through the line wire, and, passing through the coils of an instrument of precisely similar construction at the distant station, are again resolvent into air undulations by the diaphragm of this instrument."

The Providence *Journal*, of March 15, 1877, had a long article on the telephone, from which the following is an extract:—

"THE LAST GREAT WONDER.

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"In the telephone no galvanic battery is used. A permanent steel magnet is surrounded with a coil of insulated wire, and confronted with a disk of sheet iron. When the iron disk vibrates, under the influence of sound, it disturbs the magnetism of the steel magnet before it; and, by a familar law, every change of magnetism in a magnet excites an electric current in a surrounding coil. The coil is connected with the telegraphic wire, and that with the coil around the magnet at the further end of the line, the ground being used for the return circuit. The distant magnet thrills with the electric current so excited, and vibrates the disk in front of it, which, in turn, impresses sound waves on the air."

The Boston *Daily Globe*, of April 6, 1877, had a report of the Providence lecture, from which the following is taken:—

"PROFESSOR BELL EXHIBITS ITS WONDERFUL WORKINGS TO A PROVIDENCE AUDIENCE. — A SUCCESS DESPITE UNFAVORABLE CONDITIONS.—A SPECIAL TO THE 'GLOBE' BY TELPEHONE.

"Professor A. Graham Bell, the inventor of the telephone, lectured in Providence last evening; and in his little room at the top of No. 5 Exeter Place, Mr. Thomas A. Watson, the electrician, with

several members of the press and a number of gentlemen interested in science, were assembled, for the purpose of holding communication with the professor, and demonstrating anew the practical workings of the instrument.

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"The *Globe* reporter remained with Mr. Watson until a late hour; and when the audience in Providence had been dismissed, and all the visitors had left the room in this city, he was repaid for his waiting by receiving the following message from a brother reporter of the *Globe*, who went to Providence especially to send a telephonic despatch:—

"'THE EXHIBITION IN PROVIDENCE.

"'*Special to the* GLOBE *by Telephone.*

"'PROVIDENCE, R. I., April 5.

"'The bad weather prevented the exhibition from being as effective as usual; still, the audience which crowded Music Hall, and represented the best society of the city, had conclusive proof of the value of the invention. The transmission of musical sounds from the reed organ in Boston, giving "Music in Air," and other familiar tunes, was admirably perfect, and was heard distinctly all over the hall. The exhibition of singing was fairly successful; and Mr. Reeve's cornet solo, "Yankee Doodle," played at the request of one of the audience, was recognized very easily. The experiment of brass-band playing was not very successful. A conversation carried on between the Rev. Dr. Behrends here, and Mr. Watson at Boston, on the Rhode Island election, caused much merriment. Governor Lippett introduced Professor Bell, who spoke till after ten o'clock, and remained in the hall an hour after, exhibiting the telephone to a curious crowd. An effort will be made to have the lecture repeated, when, it is hoped, circumstances will be more favorable for the working of Professor Bell's invention.'

"[NOTE.—On account of damage to the wires it was impossible to send as full a despatch as was intended; but, fortunately, the accident did not happen until after the lecture had been delivered and Providence people had been satisfied of the success of the invention.]"

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The following is an extract from a report of the lecture which appeared in the Providence *Daily Journal*, of April 6, 1877:—

"PROFESSOR BELL'S LECTURE ON THE TELEPHONE.

"Music Hall was filled last evening, notwithstanding the storm, by one of our best audiences, to witness the first public exhibition of the speaking telephone in this city.

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"Professor Bell stated that in vocal utterance it is best to remove the battery, and use nothing between the telephonic instruments in Boston and Providence. The Boston office was then telegraphed to cut out the battery. While waiting for this to be done, Professor Bell explained in a few words the structure of his instrument and its history.

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"Mr. Watson next sung 'Hold the Fort,' which was switched on to the different telephones. Mr. Watson then repeated a sentence which was switched on to the telephones and generally heard. Rev. Mr. Behrends then interviewed Mr. Watson, asking him if it was stormy in Boston, also 'What time is it?' and 'Have you heard the news from Rhode Island?' Mr. Watson had not. Mr. Behrends informed him that we had an election yesterday, and 'Did you hear who was elected?' Yes, Mr. Watson had read it. 'What is the news in Boston?' Answer, 'I have not heard any.' 'Good night, Mr. Watson,' closed the conference.

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"The mysterious little box at Professor Bell's lecture contains an apparatus almost elementary in its simplicity, which answers the double purpose of transmitting and receiving sounds. It may be divided into two parts, the artificial ear and the magneto-electric transmitter. The artificial ear may be likened to a grocer's sugar funnel, of tin or other metal (having a tube of about two inches diameter), the large flaring end of which has been sealed with a circular disk of thin sheet iron. This disk is the tympanum of the artificial ear. The two-inch tube is the part which projects from the box into which you talk, and at which you listen for a reply. In-

side of the box there is a fixed, U-shaped steel magnet, whose poles very nearly approach the sheet-iron disk, keeping it in a state of tension by virtue of magnetic attraction. Around the arms of the U magnet, near its poles, are bobbins of fine insulated copper wire, which communicate together, and one of the free ends of which connects with the telegraph wire outside, and the other with the ground, for the return current. For certain reasons it is thought better, in practice, to attach small, soft iron cylinders, on which the bobbins are placed, to the poles of the fixed magnet; and the ends of these cylinders then take the place of the poles of the magnet, in close proximity to the iron disk or tympanum. This is virtually the whole apparatus. When a word is whispered into the two-inch auditory tube it causes the iron tympanum to vibrate. This disturbs the magnetism of the fixed magnet, and of its soft iron cylindrical poles. This disturbance, in its turn, induces electrical currents in the coils of fine wire and in the telegraph wire outside. At the distant station these processes are then taken up in reverse order. The induced currents, passing from the telegraph wire through the coils of the receiving instrument, disturb the magnetism of the fixed magnet there, and that sets the disk in front of it in vibration, which communicates in turn the same sound undulations to the air which originated this curious serious of transformations. In other words, the persons listening at the distant disk hear the same words, accents, tones, which were confided to the disk at the near station. It will be observed that the sound waves are converted first into mechanical vibrations of the disk, then into magnetic vibrations, then into electric currents, then back into magnetic vibrations, then into vibrations of the distant disk, and lastly into sound vibrations again,—and that these transmutations of the original sound waves between the two disks require four jumps through air spaces."

The *Sun*, *Tribune*, *Herald*, *World* and *Times*, of New York, of May 12, 1877, had long accounts of an exhibition of the speaking telephone by Professor Bell, in the presence of General Eckert, President of the Atlantic and Pacific Telegraph Company, President Gibbs, of the Dominion Telegraph Company, President Barnard and Professors Newberry and Rood, of Columbia College, and many

at the St. Denis Hotel. The following is the article from the New York *Tribune*:—

"An exhibition of the speaking telephone was given last night at the St. Denis Hotel, in this city. An invitation to exhibit the instrument here had been tendered to Professor A. Graham Bell by Professor F. A. P. Barnard, Dr. Howard Crosby, Professor Henry Morton, and two or three dozen other gentlemen eminent in the learned professions or connected with telegraphy. Before beginning his proposed course of lectures, Professor Bell invited a few of his scientific friends to be present at an informal exhibition, to show the power of the instruments. About fifty gentlemen were gathered in one of the parlors of St. Denis Hotel last evening. Among those present were President Barnard, Professor O. N. Rood, and Professor J. S. Newberry, of Columbia College; the Rev. Dr. Armitage; General Eckert, President of the Atlantic and Pacific, and the Hon. T. N. Gibbs, President of the Domestic Telegraph Company; Professor Peet, of the Deaf and Dumb Asylum; Eastman Johnson, General Gaylord, S. A. Bunce, R. H. McCurdy, F. O. Evans, and other well-known citizens. There was some delay about the proceedings, which was afterwards explained.

"Professor Barnard introduced Professor Bell to the audience, having become acquainted with the instrument and the inventor at Philadelphia. Professor Barnard stated that of all the instruments of precision and research, etc., which the group of Centennial judges, of which he was chairman, was called upon to examine, there was none that occasioned greater interest or that they regarded as of higher novelty and importance than the speaking telephone of Professor A. Graham Bell. In introducing Professor Bell to the audience, Professor Barnard said he did so with the conviction that the name of the inventor of the telephone would be handed down to posterity, with a permanent claim on the gratitude and remembrance of mankind. Professor Bell expressed himself as surprised at the size and importance of the gathering. He had at first expected only a small number of his friends, and had arranged to exhibit his telephone merely by placing one of the instruments in one room, and another in another room, in the hotel, connecting them by wires. But at a late hour he had determined upon a more complete exhibi-

tion of the character of the instrument, and had therefore sent his assistant, Mr. Gower, to Brooklyn, and hoped before long to hear that Mr. Gower had arrived somewhere in that city, and to hear it from Mr. Gower through the telephone. While Professor Bell was speaking, a sound was heard from the instrument; he placed his ear against it, and after listening for a moment, said to the audience: 'It is all right. Mr. Gower has been in search of a cornet player, and thinks he will have one to play a tune for us.' Professor Bell then carried on a brief conversation with Mr. Gower, finally desiring the latter to be in readiness after a short interval, in which Professor Bell proposed to explain some features of the instrument to his audience.

"Professor Bell mentioned many facts with which our readers are already familiar, as to the construction and character of the instrument. When a magnet approaches a bar of iron, it generates a current or a change of electrical condition in the iron; when it is drawn back it generates the converse electricity: *i. e.*, in the one case positive, in the other negative. What Professor Bell had done was to substitute a sheet or plate of iron for the bar, to make that vibrate instead of the magnet, and to keep the magnet stationery. The vibration was communicated to the plate in front of the poles of the magnet by the waves of sound striking on the plate. These differences of positive and negative electricity, transmitted through the wire, caused a magnet at the other end of the wire to attract or repel a precisely similar iron plate; and the vibrations of that, communicated to the air, were sounds precisely corresponding to those presented at the first plate. He has tested it on two hundred and fifty-eight miles of wire between New York and Boston. He commenced by understanding it; now he does not understand it.

"The vibration was supposed to be like that of a membrane, such as is that of the drum of the ear. But we all know that such vibration can be readily dampened by fastening upon the membrane something to stiffen it.

"There was no such result with the telephone when a wooden ring was screwed to the plate; or when the plate itself was made of extraordinary thickness, the vibration is molecular. The curious sounds heard in the telephone were described; some of them had

been ascertained to proceed from earth currents. The instrument was more sensitive than a galvanometer to certain imperfections in the wire, or imperfect connections.

"The cornet player at last arrived. He was borrowed for a brief period from the orchestra of a neighboring theatre. He played two tunes, the latter one being very distinctly heard. When the note happened to strike the fundamental note of the telephone box it sounded abnormally loud. Otherwise it was fairly rendered. The voice in Professor Bell's instrument sounds very much as though it had come through a very long speaking-tube. Some practice is necessary to catch the words uttered, the vibrations giving a sort of confusing rattle. Nevertheless, the success of the transmission is unquestionable.

"After Professor Bell finished speaking, the different members of the audience listened at the instrument, and some of them conversed with Mr. Gower, who was at the telegraph office, No. 340 Fulton Street, Brooklyn. Much laughter was occasioned by Professor Bell getting the word Fulton wrong, after asking Mr. Gower where he was; Professor Bell understood him to say 'Beacon Street,' perhaps having Boston in his mind. The proprietors of the St. Denis Hotel invited the visitors to a repast after the exhibition."

The first New York lecture was given May 17, 1877, at Chickering Hall, and long reports of it were in the New York *Herald*, *Tribune*, *World* and *Times* of the next day. These reports stated that President Barnard and Professor Rood, of Columbia College, President Morton and Professor Mayer, of the Stevens Institute, Mr. Cyrus W. Field, Mr. William Orton and General Eckert, and Messrs. Preece and Wheeler (of the English Postal Telegraph) were present and that Mr. Field spoke through the telephone to the operator at Brunswick.

The lecture in New York, at Chickering Hall, was preceded by the following request, the original of which is before me, which was published in the daily papers, and will be produced if required:—

"NEW YORK, April 7, 1877.

"Professor A. GRAHAM BELL, *Boston University:*

"*Dear Sir*,—The interest excited during the Centennial Exhibition by your experiments with your telephone, holding communications in audible speech with persons many miles away, and the published accounts of your improvements in the wonderful instrument, prompt us to request that you will deliver in our city, on some evening convenient to yourself, a lecture on sound and electricity, with an exhibition of your speaking telephone, showing what can be done by it, and making known its scientific and commercial value.

"Very truly, etc.,

"F. A. P. BARNARD [*President Columbia College*].
HOWARD CROSBY [*Chancellor of New York University*].
HENRY MORTON [*Stevens Scientific School*].
E. L. YOUMANS [*Ed. Popular Science Monthly*].
CYRUS W. FIELD [*Atlantic Cable*].
THOS. T. ECKERT [*Pres. Atlantic and Pacific Tel. Co.*].
A. M. MAYER [*Stevens Scientific School*].
WILLIAM ORTON [*Pres. Western Union Tel. Co.*].
J. S. NEWBERRY [*School of Mines, Columbia College*].
C. T. CHANDLER [*Prof. Chemistry, College Phys. and Surgeons*].
H. D. NOYES [*Prof. Aural Surgery, Bellevue College*].
JNO. W. DRAPER [*Prof. Chemistry, N. Y. University.*]"

At Boston three lectures were given in the Music Hall in May, 1877, at the first of which Professor Bell was introduced by Governor Gaston, and at each of them articulate speech was publicly transmitted. The exhibitions at Boston and Providence were reported in the principal newspapers: *e. g.*, Providence *Journal* of April 6, 1877, the Boston papers of April 6, and of May 5, 8, 9, of 1877.

The Boston lectures were preceded by the following, which was published in the daily papers, and will also be produced when required:—

"BOSTON, April 20, 1867.

"Professor ALEXANDER GRAHAM BELL:

"*Sir*,—The undersigned, having followed with great interest the accounts of your discoveries and inventions in connection with the electric telephone, which have from time to time appeared in the newspapers, and confident that the general public of the city in which your researches have been made will be glad to witness a practical exhibition of your telephone under your direction, respectfully request you to gratify this desire of your fellow-citizens at such time and place as may be most convenient to you.

"BENJAMIN PIERCE [*Prof. Mathematics, Harvard College*]
JOSEPH LOVERING [*Prof. Physics, Harvard College*].
E. N. HORSFORD [*formerly Rumford Prof., Lawrence S. School*].
HENRY W. LONGFELLOW [*Cambridge*].
GEO. B. EMERSON [*Boston*].
O. W. HOLMES [*Boston*].
CHARLES W. ELIOT [*Pres. University at Cambridge*].
ALEXANDER H. RICE [*Governor of Massachusetts*].
NEHEMIAH GIBSON [*Boston*].
FREDERICK O. PRINCE [*now Mayor of Boston*].
WILLIAM F. WARREN [*Cambridge*].
JOHN D. RUNKLE [*Mass. Inst. Technology and Naut. Al.*].
C. F. ADAMS [*Quincy*].
WOLCOTT GIBBS [*Prof. Lawrence Scientific School*].
EDWARD C. PICKERING [*Prof. Physics Mass. Inst. Tech., now Director of the Observatory at Cambridge.*]"

I will refer to the following publications, though I was not present on the occasions described:—

Dr. Henry Morton gave a lecture on the telephone, and an abstract of it is in the New York *Herald* of June 14, 1877.

The *Journal of the Telegraph*, March 1, April 1, April 16 and May 16, 1877, describe and refer to Mr. Bell's electric speaking telephone, and to Mr. Bell as the inventor thereof.

The *Popular Science Review*, an English publication, for 1877, p. 429, has an article of four pages on electric speaking telephones, in which it says:—

"THE TELEPHONE.—During the recent session of the British Association at Plymouth, the lion's share of attention was unquestionably given to the telephone. Wherever the instrument was to be exhibited, whether in the physical or in the mathematical sections, or at Mr. Preece's popular evening lecture, there were always crowded audiences, eager to learn something about so novel an apparatus. At the *soirées*, too, the telephone stood above everything else as the center of attraction, and knots of people were crowded round the instrument, anxious to converse with friends in distant apartments. The interest in this subject culminated on the arrival of Professor Graham Bell, the inventor of the talking telegraph."

The Mr. Preece referred to is, I presume, Mr. W. H. Preece of the English Postal Telegraph, vice-president of the Society of Telegraph Engineers. A paper by him on the telephone was published in the *Philosophical Magazine* for April, 1878. It begins as follows:—

"The introduction of the speaking telephone, by Alexander Graham Bell, has supplied physicists with an instrument of research, as well as with an instrument of practical utility."

I have before me a pamphlet by Professor W. F. Barrett, F. R. S. E., read Nov. 19, 1877, before the Royal Dublin Society, and reprinted from their *Proceedings*. It says:—

"The various attempts to communicate audible speech by means of electricity have culminated in the recent discovery by Professor Graham Bell of the articulating telephone. The discovery was not the result of chance, but of long and patient endeavor. . . .

"These experiments revealed to Professor Bell the important point, that the transmission of speech by electricity could only be accomplished by using what may be termed an undulatory current; that is to say, one that merely varied in strength, without the occurrence of any actual interruptions which would give rise to a discontinuous or intermittent current. It is this principle of an unbroken current which distinguishes Bell's telephone from all preceding efforts.

"The electric currents in this telephone are in simple proportion to the motions of the air produced by the voice, and further, the electric waves sent to the distant extremity are (by a receiving

arrangement precisely similar to the transmitting instrument) caused to reproduce motions of the air identically the same in character as those that gave birth to the currents. Thus, not only is articulation heard perfectly, but moreover, the different qualities of different voices are heard, so that at fifty or one hundred miles' distance the individuality of the speaker is transmitted as well as his ideas."

The *Scientific American* of Oct. 6, 1877, has a long article entitled "The New Bell Telephone." It is illustrated by large wood-cuts of the hand telephone now in common use, and of the manner of using the same. Said article describes the structure of the apparatus, and its mode of operation. It concludes with the following paragraph:—

"The telephone has advanced considerably beyond the status of a 'beautiful scientific toy,' which many hastily pronounced it, and is now in constant use in numerous private lines in New York, Boston, and Providence. Professor Bell recently exhibited it before the British Association at Plymouth, England, where it attracted great attention. It is at present manufactured by the Telephone Company, of New York, Mr. Charles A. Cheever, manager, 32 Tribune Building, in this city."

I annex the opening paragraph of a long article, under the caption of "The Telephone," which appeared in the Westminster *Review* for January, 1878 (page 208):—

"Of all modern inventions connected with the transmission of telegraphic signals, the telephone, devised by Mr. Alexander Graham Bell, has excited the most widespread interest and wonder. Wherever Mr. Bell has appeared before the public to give an account of his invention and the researches which have led up to it, crowds have assembled to hear him. Nor is this astonishing; for the telephone professes not only to convey intelligible signals to great distances without the use of a battery, but to transmit in *fac simile* the tones of the human voice, so that a voice shall be as certainly recognized when heard over a distance of a few hundreds of miles as if its owner were speaking in a room by our side. And the telephone does not fall short of its profession. Scientific men have had their wonder and curiosity aroused even more

than the unscientific public, since a scientific man appreciates the enormous difficulties to be overcome before such an instrument can be realized. Had any hardy speculator a few years ago proposed a telephone which should act on the principle and be constructed in the form of Mr. Bell's instrument, he would probably have been considered a lunatic." . . .

*Int.* 12. In Mr. Bell's deposition he speaks of the transmission of articulate speech from Boston to Providence, on the occasion of the lecture and exhibition at Providence, which you have described in your last answer. Please to state whether you took any part in that transmission; and if so, what?

*Ans.* I was at the Boston end of the line, and had entire charge of the experiments by which the lecture was illustrated, and I conversed with a large number of people in Providence, and succeeded in making my voice audible to a large part of the audience at once.

*Int.* 13. Please state what, if anything, you had to do with the transmission from Providence to Boston of a report of the Providence exhibition, which was published in the Boston *Globe*, a copy of which you have already given.

*Ans.* I received it by telephone.

*Int.* 14. The account in the *Advertiser*, Oct. 9, 1876, of the use of the telephone between Boston and Cambridge, speaks of it as the first occasion where conversation was carried on over a telegraph wire. Is that strictly correct, or in what way did that use of the instrument differ from the uses you and Mr. Bell had previously made of it?

*Ans.* No; it was not strictly correct. Mr. Bell had several months previously, in Canada, carried on conversation over a telegraph wire; and before Oct. 9 we had often carried on conversation over a local circuit. The article in the *Advertiser* of Oct. 9, 1876, gives the first recorded conversation over a telegraph line.

[*Testimony as to use in Canada objected to as incompetent by counsel for Gray, and also by counsel for Edison.*]

*Int.* 15. What do you mean by the phrase "telegraph line," or "telegraph wire," as distinguished from a "local circuit"?

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*Ans.* By telegraph line I mean one running out of doors. By a local circuit I mean a circuit connecting different points within one building.

*Int.* 16. I now call your attention to the use by Mr. Bell and his licensees of electric speaking telephones provided with metallic diaphragms; and I wish you would state some early instances of uses in public, or uses to which publicity was given, of instruments constructed with metallic diaphragms, and refer to the publications which describe such uses. Please answer, first, as to instances before April 1, 1877.

*Ans.* Referring to my answer to Int. 11, all the instruments used at the public exhibitions therein described, from Jan. 1 to April 1, 1877, had metallic diaphragms. In addition to that I will state some other uses of telephones with metallic diaphragms:—

Mr. Bell's magnet receiver, used as part of his speaking telephone apparatus, exhibited and used at the Centennial Exposition, had a diaphragm entirely of soft iron. One like it, with a soft iron diaphragm, was given by him to Sir William Thomson, and described by that gentlemen in his address before the British Association in August, 1876, a copy of which, taken from the Boston *Daily Advertiser* of Sept. 25, 1876, has already been given. A description of the same, with woodcuts, is in the *Scientific American* supplement of Feb. 10, 1877. These woodcuts are reproduced in Mr. Prescott's book on the "Telephone," page 101, in a reduced size, and are given on p. 29, *supra*. This thin metallic iron disk, in combination with the electro-magnet, is also described as the receiver used at the Centennial in the official report on awards, prepared by Sir William Thomson, already quoted on p. 25, *supra*. I have already described and given some newspaper accounts of the use of Mr. Bell's telephone between Boston and Cambridge in October, 1876. Metallic diaphragms were then used in those instruments.

The instruments exhibited in operation before the Washington Philosophical Society, Jan. 13, 1877, had metallic diaphragms. An extract from a report of this in the Washington *Evening Star* of Jan. 20, 1877, has already been given.

All the telephones, the use of which has been mentioned in this deposition as occurring after that date, had metallic diaphragms.

Among the uses of those telephones with metallic diaphragms, which took place in the presence of a large number of persons and received publicity through the newspapers, I mention the following, which are already referred to in this deposition:—

Report in Boston *Evening Transcript* of Feb. 1, 1877; report of lecture at Salem, Feb. 12, 1877, was transmitted by telephone, and which was transmitted and received in the presence of a large number of persons.

Another lecture at the same place, Feb. 23, 1877, was reported in the *Globe* of Feb. 24, 1877, the report transmitted by telephone in the presence of a large number of persons. At all the subsequent lectures mentioned in this deposition the public generally attended, paying admission fees; and large numbers of the audience were at liberty to, and actually did, transmit and receive articulate speech through telephones with metallic diaphragms. The character and construction of the diaphragm, and the fact that the *Globe* report was transmitted by it, is described and told in an extract from the *Globe* of Feb. 15, 1877, given in a former answer, p. 44. Such telephones were publicly used in New York, May 11, 1877, and a description of the use and of the instrument, mentioning the iron plate, was given in the New York papers of the next day; an extract from the *Tribune* report has been given on p. 55.

Other public uses of the speaking telephone with metallic diaphragms were made in New York, May 17, 18 and 19, 1877, and reports of their use are in the New York papers of the next day. These reports stated that the audience publicly transmitted and received speech by them.

*Int.* 17. Please state whether Mr. Bell and his associates made, with your knowledge, in the spring of 1877, any arrangements for the manufacture of electric speaking telephones, under his patents, and with metallic diaphragms for general commercial use; and if so, state whom they arranged with for their manufacture.

*Ans.* Mr. Bell and his associates made an arrangement with Charles Williams, Jr., of Boston, for the manufacture of such telephones some time previous to April 1, 1877.

*Int.* 18. Was any arrangement made with Mr. Williams to act as

agent for Mr. Bell and his associates in putting out telephones for private lines; if so, what was the nature of the arrangement?

*Ans.* An arrangement was made prior to April 1, 1877, by which Mr. Williams obtained the right to supply the public with telephones made under Bell's patents. He was to be allowed a commission on all he leased.

*Int.* 19. Please state the first line that was put up in the vicinity of Boston for the use of such telephones on it; giving any extracts from newspapers or other publications which you may have relating to it.

*Ans.* Before April, 1877, a line of wire was built from Boston to Somerville, for the express purpose of being used with telephones. It is correctly described in the following newspaper extracts:—

BOSTON DAILY ADVERTISER.

APRIL 5, 1877.

"The first telephone line that was ever established has just been constructed between the office of Mr. Charles Williams, electrician, in this city, and his house in Somerville, and a conversation can be carried on with perfect distinctness. Mr. Bell was in New York on Tuesday evening, and conversed readily over the regular wires with parties in this city. He lectures in Providence this evening, on Telephones."

BOSTON POST.

THURSDAY MORNING, APRIL 5, 1877.

"The telephone has been put into practical use; yesterday a line was opened from the office of Charles Williams, Esq., 109 Court Street, to his house in East Somerville. The great value of this invention is thus manifested, for by its uses Mr. Williams is now able to converse with his family when separated from them by fully three miles of distance."

THE BOSTON DAILY GLOBE.

APRIL 5, 1877.

"PERFECTING THE TELEPHONE."

"Professor A. Graham Bell, the inventor of the telephone, had the pleasure of assisting at the opening of the first regular telephone line

in the world, a private line between the place of business of a gentleman in this city and his residence in Somerville. The instrument worked admirably, and the enterprising gentleman is very much pleased with his private telephonic wire between town and home. The practical value of Professor Bell's invention is being newly proved every day.

"While the Professor was in New York recently, he communicated with his associate in Boston, Mr. Watson, and the telephone transmitted conversation over 280 miles of space with wonderful clearness and distinctness of sound."

THE BOSTON HERALD.

APRIL 5, 1877.

"The first telephone line ever established has just been constructed between the office of Mr. Charles Williams, electrician, in this city, and his house in Somerville."

THE BOSTON TRAVELLER.

APRIL 5, 1877.

"The first telephone line ever established has just been constructed between the office of Mr. Charles Williams in this city and his house in Somerville."

The telephones used on this line had metallic diaphragms. The owners of Mr. Bell's patents were about to manufacture largely for general commercial use, and this line was constantly used for the public to talk over that they might be induced to buy or hire telephones. Such use by the public was made largely in April, 1877.

*Int.* 20. Please to describe some other lines that were used for Mr. Bell's telephones in April or the early part of May, 1877; and give any newspaper extracts you may have relating to them; and if you wrote and published any circular or advertisement relating to telephones for commercial use, please give a copy of it; and state generally what exertions were made in the way of putting telephones on the market for sale or on lease during May, 1877.

*Ans.* Between April 20 and 30, 1877, a line was built connecting the laboratory of Professor Bell, No. 5 Exeter Place, with the office of Charles Williams, Jr., No. 109 Court Street; and, about the same time telephone connection was made between said laboratory and

the office of Stearns & George, 37 Pearl Street. These lines were specially erected for the business convenience of the parties interested, and were fitted up with telephones, all of which had metallic diaphragms.

JOURNAL OF THE TELEGRAPH.

APRIL 16, 1877.

"The first regular telephone line has been put in operation between the place of business of Mr. C. Williams, 109 Court Street, Boston, Mass., and his residence in Somerville, a distance of about three miles. Mr. Williams states that it works well, and that 'conversation can be carried on by it nearly as well as if in the same room.'"

About May 1, 1877, telephones with metallic diaphragms were put on a line connecting the office of Stone & Downer, 28 State Street, Boston, with the residence of one of the parties in Somerville, concerning which they addressed the following letter to Mr. Gardiner G. Hubbard, who at that time had charge of the business interests under the Bell patents:—

"OFFICE OF STONE & DOWNER, CUSTOM HOUSE BROKERS AND FORWARDERS, DEALERS IN SPECIE, GOVERNMENT BONDS AND STOCKS, EXCHANGES ON THE PROVINCES AND SAN FRANCISCO, 28 STATE STREET, BOSTON, MAY 14, 1877.

"GARDINER G. HUBBARD, Esq., Cambridge, Mass.:

"*Dear Sir*,—In reply to your inquiry regarding the use of the telephone, I would state that we placed them on our line between Boston and North Somerville some two weeks ago; we have used them constantly since with good success; in fact, we have become so used to them that we use them in preference to the 'Morse System,' being able by the use of the telephone to transmit our messages much faster, and with a great deal less labor. We have experimented several times with musical instruments, and in each case have been attended with remarkable success; the playing of a piano being heard very distinctly, and no difficulty experienced in distinguishing the piece being played. We can certainly indorse the telephone as a success, and believe it can be used practically with many advantages over the old system of telegraphy.

"Yours, respectfully,

"R. C. & F. W. DOWNER."

The inquiry of Mr. Hubbard referred to in said letter was with the view of drawing out a reply from the Messrs. Downer for publication, in a circular then in course of preparation, and which was immediately thereafter printed for general circulation and widely distributed, which circular was in the following words:—

"THE TELEPHONE.

"The proprietors of the telephone, the invention of Alexander Graham Bell, for which patents have been issued by the United States and Great Britain, are now prepared to furnish telephones for the transmission of articulate speech through instruments not more than twenty miles apart. Conversation can be easily carried on, after slight practice, and with the occasional repetition of a word or sentence. On first listening to the telephone, though the sound is perfectly audible, the articulation seems to be indistinct; but, after a few trials, the ear becomes accustomed to the peculiar sound, and finds little difficulty in understanding the words.

"The telephone should be set in a quiet place, where there is no noise which would interrupt ordinary conversation.

"The advantages of the telephone over the telegraph for local business are:—

"*First.* That no skilled operator is required, but direct communication may be had by speech, without the intervention of a third person.

"*Second.* That the communication is more rapid, the average number of words transmitted a minute by Morse sounder being from fifteen to twenty; by telephone, from one to two hundred.

"*Third.* That no expense is required, either for its operation, maintenance or repair. It needs no battery, and has no complicated machinery. It is unsurpassed for economy and simplicity. The terms for leasing two telephones for social purposes, connecting a dwelling house with any other building, will be $20 a year,—for business purposes $40 a year,—payable semi-annually in advance, with the cost of expressage from Boston, New York, Cincinnati, Chicago, St. Louis or San Francisco. The instruments will be kept in good working order by the lessors, free of expense, except from injuries resulting from great carelessness.

"Several telephones can be placed on the same line at an additional rental of $10 for each instrument, but the use of more than two on the same line where privacy is required is not advised. Any person within ordinary hearing distance can hear the voice calling through the telephone. If a louder call is required, one can be furnished for $5.

"Telegraph lines will be constructed by the proprietors if desired. The price will vary from $100 to $150 per mile; any good mechanic can construct a line. No. 9 wire costs 8½ cts. a pound, 320 pounds to the mile, 34 insulators at 25 cts. each; the price of poles and setting varies in every locality; stringing wire $5 per mile, sundries $10 per mile.

"Parties leasing the telephones incur no expense beyond the annual rental and the repair of the line wire. On the following pages are extracts from the press and other sources relating to the telephone.

"GARDINER G. HUBBARD,
"Cambridge, Mass.

"MAY, 1877.

"For further information and orders address Thos. A. Watson, 109 Court St., Boston."

In addition to the foregoing this circular contained a long extract from the reports on awards of the judges of the Centennial Exhibition, Sir William Thomson, chairman; a series of resolutions adopted by the Essex Institute, Feb. 19, 1877, relative to the telephone; an extract from the Providence *Evening Press* of March 19, 1877, giving an account of successful experiments by Professor Bell in talking through the telephone over a line forty-three miles long; an extract from the New York *Herald* of May 12, 1877, giving a description of an exhibition by Professor Bell at the St. Denis Hotel, and the letter of Messrs. R. C. & F. W. Downer, above given in full. In the New York *Graphic* of Wednesday, May 23, 1877, appeared the following article relative to the practical use of the telephone, from which it is evident that this circular had at that date reached New York:—

THE DAILY GRAPHIC, NEW YORK.

WEDNESDAY, MAY 23, 1877.

"The telephone is quickly working out a practical application. A Boston company is prepared to furnish telephonic communication between places not over twenty miles apart. The advantages are thus set forth: no skilled operator employed; a little practice makes any one master of the telephone; communication more rapid, the telephone transmits one or two hundred words per minute; the old telegraph apparatus averages not more than twenty; no expense required in its operation; no battery needed; two telephones connecting two houses may be leased for $20 per year. The company keep the instruments in working order. It must be understood that the rental mentioned above is for the use of the telephonic instrument. A telegraph line, when required, will cost from $100 to $150 per mile."

In the early part of May, 1877, an arrangement was made with the Cambridge Board of Water Works for putting up telephones on a line connecting their office in Cambridge with the works at Fresh Pond. This practical use of the telephone for public purposes was referred to as follows, in a Boston newspaper of May 19:—

THE BOSTON HERALD.

MAY 19, 1877.

"PRACTICAL USE OF THE TELEPHONE.

"A telephone is to be placed in the City Hall, Cambridge, in the office of the Water Board, to establish communication with the water works at Fresh Pond. A line of wire has been constructed, it being originally intended for the use of the printing telegraph. At the suggestion of Hon. Gardiner G. Hubbard, a telephone is to be substituted, that gentleman guaranteeing that the city shall be subjected to no expense unless the machine proves satisfactory."

BOSTON DAILY ADVERTISER.

MAY 19, 1877.

"THE FIRST PRACTICAL APPLICATION OF THE TELEPHONE.

"The Water Board of Cambridge has decided to have telephone

communication with the water works at Fresh Pond, in order to facilitate the sending of messages. The Board has accepted the offers of Mr. Gardiner G. Hubbard to place the telephone in operation, the city to be at no expense unless the arrangement proves satisfactory. Mr. Hubbard was formerly President of the Board, and feels interested in having Cambridge first to apply the wonderful invention to public service."

In the early part of May, 1877, telephones with metallic diaphragms were put up on lines, connecting the office of E. T. Holmes, Washington Street, Boston, with the banking house of Brewster, Bassett & Co., Congress Street, and the office of Charles Williams, Jr., 109 Court Street. These lines were intended to demonstrate the value of the telephone in connection with the burglar and fire-alarm systems of Mr. Holmes, and a public exhibition of the same was given on the seventeenth day of May following, notice of which appeared in a Boston newspaper of the next day. The telephones used on that line had metallic diaphragms.

BOSTON EVENING TRANSCRIPT.

MAY 18, 1877.

"THE TELEPHONE.

"Another successful series of experiments with the telephone was made yesterday afternoon at the rooms of Professor Holmes, electrician, on Washington Street. At this place Mr. T. M. Carter played several cornet solos, which were distinctly heard at the rooms of Messrs. Brewster, Bassett & Co., on Congress Street, at a branch office on Court Street, and in Somerville.

"In response, Mrs. Williams sang several songs in Somerville, which were plainly heard at these points above mentioned in this city. And singing from the Court Street office was heard in all the other places. Conversation was also carried on between the several points connected, with perfect ease."

On the eighteenth day of May, 1877, I personally put up a tele-

phone in the office of H. L. Roosevelt, No. 40 West 18th Street, New York, connecting with another telephone supplied by Professor Bell at said Roosevelt's residence, both of which had metallic diaphragms.

On Monday, the twenty-first day of May, 1877, in pursuance of an arrangement made some time prior thereto, I put up telephones, with metallic diaphragms, on a line in Altoona, Penn., going from New York specially for that purpose.

All the lines above referred to as erected in April and May, 1877, were put up for practical business purposes, and were so used from the date of their construction.

During the months of April and May, 1877, Mr. Hubbard was constantly negotiating for the disposal of exclusive privileges, territorial licenses, etc., under the Bell patents, and for supplying telephones with metallic diaphragms for commercial use. In April, or before, we made an agreement with Charles Williams, Jr., and the firm of Stearns & George, by which these parties acquired a right to the private line telephone business for Boston and vicinity within a radius of ten miles.

Before May 1, 1877, said Hubbard was negotiating with Charles A. Cheever and others to supply telephones to them for general commercial use in New York City; with Russell & Kinsman for their use in Boston; with E. T. Holmes for the use of the telephone in Boston in his bank and express business; and with a great number of parties whose names I do not now recall, for territorial privileges in various parts of the country. The offers made to these persons by Mr. Hubbard in April and May were to furnish telephones to them to be used on lines, which they were to put up for any customer who might apply.

*Int.* 21. Please state when the circular referred to in your last answer or its contents were advertised or made public.

*Ans.* Some time prior to May 16, 1877.

*Int.* 22. How do you fix that date?

*Ans.* The circular was prepared by Mr. Gardiner G. Hubbard, Mr. Bell's business manager, and an abstract from the circular was published in the New York *Graphic*, of May 23, 1877, a copy of which has been given in my previous answer. These circulars were

sent out by Mr. Hubbard from Boston; and as Mr. Hubbard had left Boston on May 16, to attend the lectures of Mr. Bell in New York on the 17th, 18th and 19th, and on the 20th went to Altoona, Penn., with me, to put up telephones, and went directly from Altoona to Washington, I am certain they were mailed before he left Boston.

*Int.* 23. Did you put up any electric speaking telephones with metallic diaphragms at Altoona, Penn., in May, 1877; if so, when, and for whom?

*Ans.* I put up a set of such telephones Monday, May 21, 1877, for Mr. Gardner, superintendent of the Pennsylvania Railroad.

*Int.* 24. State, if you know, how early the arrangement to put up those telephones was made between Mr. Bell and his associates and the Pennsylvania Railroad, and when you received your directions to go to Altoona and put them up.

*Ans.* The arrangement was made before Mr. Hubbard left Boston, May 16, 1877; I received my instructions May 18 or 19.

*Int.* 25. Some extracts from the Cambridge and Boston papers of May 19, 1877, given in your previous answers, refer to Bell telephones used, or to be used, by the Cambridge Water Board. Will you state when that arrangement was made, and how you fix the date?

*Ans.* The arrangement was made between Mr. Hubbard and the Water Board early in May, 1877. It was made before Mr. Hubbard left for New York, May 16, 1877.

*Int.* 26. One of your previous answers refers to telephones put up for Mr. Roosevelt in New York, May 18, 1877. State whether or not you put them up, or superintended putting them up, and how positively you can fix the date.

*Ans.* I put up one of them myself. Mr. Roosevelt put up the other. We immediately used the line, and it worked very satisfactorily. I am able to fix the date, May 18, 1877, as the telephones were put up during the New York lectures, already mentioned; and the first and last days, the 17th and 19th, I was too busy to do anything but attend to preparations for the lectures.

*Int.* 27. State what kind of diaphragms were in the instruments you

have described as having been made, furnished or put up between Jan. 1, 1877, and June 1, 1877.

*Ans.* The diaphragms in those instruments were composed entirely of soft iron.

*Int.* 28. The extracts from the *Advertiser* and the *Globe*, of April 5, 1877, given in your answer to Int. 19, refer to the transmission of articulate speech over the regular wires between New York and Boston a few days before. Please state whether or not such transmission took place, and whether you took part in it.

*Ans.* Such transmission took place, as described. I was at the Boston end of the line and talked with Mr. Bell in New York.

*Int.* 29. Please describe the telephone that was used on that occasion.

*Ans.* It was what was called a box telephone, consisting essentially of a large permanent magnet, with coils of wire on its ends and a diaphragm of soft iron, fastened on a wooden block behind a mouth-piece, and the whole covered with a thin wooden box. It is essentially like the drawing, defendant's Exhibit Bell Telephone A, p. 772, Vol. II of the record in the Dowd case. That drawing, however, shows the instrument with its cover off in order to exhibit its interior. In practice a wooden cover like a box went over the whole interior part, which was screwed on to the base, and this is what gave it the name of box telephone. As we progressed the telephones were gradually made neater and smaller. I have here before me, on the table, box telephone No. 39, which was made in June, 1877. A sectional cut of this will be made part of my answer. In this the cores of the coils are prolongations of the magnet. They were afterwards placed on the side of the magnet, and the position of the diaphragm and mouth-piece changed, so as to occupy the same position in relation to the cores as in No. 39. This much reduced the size of the instrument and allowed it to be screwed directly to the wall. The change was made about Aug. 1, 1877. I produce one, No. 251.

Those used at the lectures in the spring of 1877 were substantially like the exhibit, but were much larger. The first modification was to reduce the size of the box and the magnet; then to change the position of the cores on the magnet, and about the middle of

## "BELL TELEPHONE A," PAGE 772 OF DOWD CASE.

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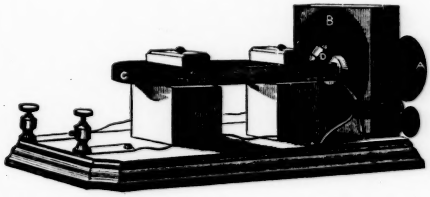


A. Speaking Tube.
B. Metallic Diaphragm.
C. Permanent Magnet.
D. Signal Call.

DIMENSIONS.

| | |
|---|---|
| Length of permanent magnet . . . . . | $7\frac{1}{4}$ inches. |
| Length of spool . . . . . | $\frac{3}{8}$ " |
| Diameter of spool . . . . . | $1\frac{1}{8}$ " |
| Diameter of diaphragm . . . . . | $4\frac{1}{4}$ " |
| Length of speaking tube . . . . . | $3\frac{1}{4}$ " |

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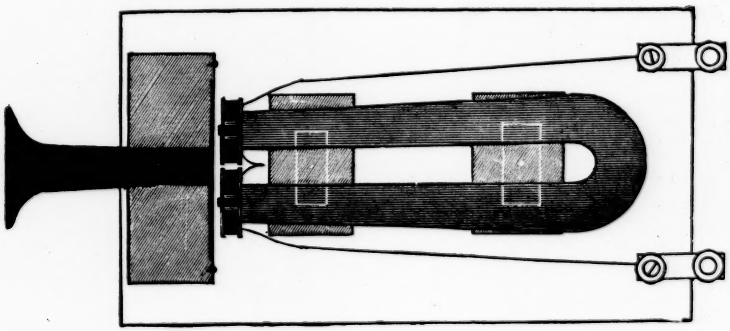
## BOX TELEPHONE (No. 39) OF JUNE, 1877.



DIMENSIONS.

| | |
|---|---|
| Length of permanent magnet (including core) . . | $7\frac{5}{8}$ inches. |
| " spool . . . . . | $\frac{1}{4}$ " |
| " core . . . . . | $\frac{5}{16}$ " |
| Diameter of spool . . . . . | $1\frac{1}{8}$ " |
| " core . . . . . | $\frac{1}{4}$ " |
| " diaphragm . . . . . | $4\frac{3}{16}$ " |
| " sound chamber . . . . . | $3\frac{3}{8}$ " |
| Depth of sound chamber . . . . . | $\frac{1}{16}$ " |

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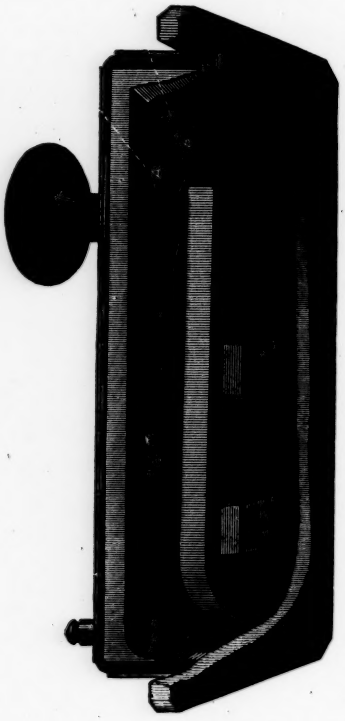
## BOX TELEPHONE (No. 251) OF AUGUST, 1877.

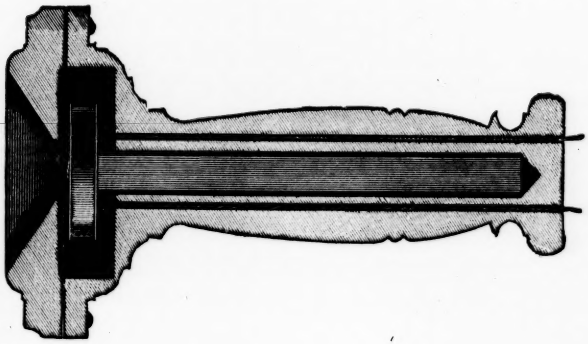


A. Diaphragm broken off to show sound chamber.
B. Sound chamber.

### DIMENSIONS.

| | |
|---|---|
| Length of permanent magnet . . . . . | 7 inches. |
| " spool . . . . . | $\frac{3}{8}$ " |
| " core . . . . . | $\frac{7}{16}$ " |
| Diameter of spool . . . . . | 1 " |
| " core . . . . . | $\frac{1}{4}$ " |
| " diaphragm . . . . . | $4\frac{1}{8}$ " |
| " sound chamber . . . . . | $3\frac{3}{8}$ " |
| Depth of sound chamber . . . . . | $\frac{1}{16}$ " |

## HAND TELEPHONE (No. 10) OF MAY, 1877.



DIMENSIONS.

| | |
|---|---|
| Length of permanent magnet . . . . . | $4\frac{1}{4}$ inches. |
| " spool . . . . . | $\frac{1}{4}$ " |
| Diameter of spool . . . . . | $1\frac{1}{8}$ " |
| " diaphragm (in the clear) . . . | $1\frac{3}{4}$ " |

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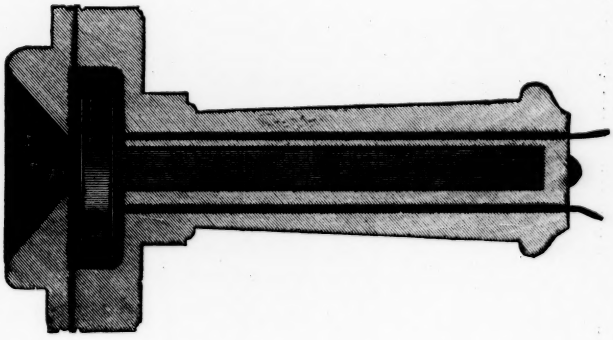
## HAND TELEPHONE (No. 18) OF JUNE, 1877.



DIMENSIONS.

| | |
|---|---|
| Length of permanent magnet . . . . . | $4\frac{1}{16}$ inches. |
| " spool . . . . . | $\frac{1}{4}$ " |
| Diameter of spool . . . . . | $1\frac{1}{8}$ " |
| " diaphragm (in the clear) . . . | $1\frac{3}{4}$ " |

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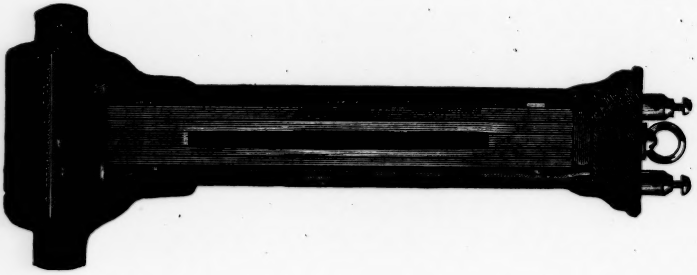
## RUBBER HAND TELEPHONE, IN USE SINCE DEC., 1877.



DIMENSIONS.

| | | |
|---|---|---|
| Length of permanent magnet . . . . . | $4\frac{3}{4}$ | inches. |
| " soft-iron core . . . . . | $\frac{9}{16}$ | " |
| " spool . . . . . | $\frac{1}{2}$ | " |
| Diameter of spool . . . . . | 1 | " |
| " core . . . . . | $\frac{1}{4}$ | " |
| " diaphragm (in the clear) . . . . | $1\frac{3}{4}$ | " |

May, 1877, we began to make the form of telephone known as the hand telephone. I have one here, which I now produce for inspection. No. 10 of the manufacturer's series of hand telephones was made in the last of May or first of June. I insert sectional cut as part of my answer. In this telephone the magnet is a solid single pole steel magnet, about four inches long. The core is about a quarter of an inch in diameter and half an inch long; formed by reducing the diameter of the steel magnet with a coil about three eighths of an inch long and one and a quarter in diameter of insulated wire. Resistance, sixty-five ohms. The diaphragm of thin soft iron about two inches in diameter. The whole is mounted in a wooden handle, similar in shape to a butter stamp, so that it can be easily handled.

After this form, No. 10, we modified the shape of the hand telephone, making it a little larger and a plainer shape, with a rather deeper flare at the mouthpiece. This change was made early in June, 1877. I produce one of this form, No. 18 of the manufacturer's series, a cut of which I insert as part of my answer.

About the middle of December, 1877, we gave up wood as a material for the handles of hand telephones, and adopt hard rubber of substantially the form now in use.

I will also add, that about the middle of August, 1877, we changed from single bar magnets to compound bar magnets made up of several layers of magnetized steel, which was stronger and easier to magnetize than the single bar magnet.

My recollection is very strong that no hand telephones were actually put out for commercial use before the first of June, 1877, or within a few days of that time.

*Int.* 30. Will you state about how many magneto-telephones are now in use in this country as transmitters?

*Ans.* About twenty-five thousand are so used, without counting those used in connection with Blake transmitters as receivers, which are often used as transmitters in case of temporary derangement of the Blake transmitters. I have in mind one instance of the use of magneto-telephones as transmitters. The Massachusetts Institute of Technology has recently been fitted with telephones on lines connecting

their various departments,—about twenty stations. At all these stations, magneto-telephones are used as transmitters and give perfect satisfaction.

*Int.* 31. Please state how many electric speaking telephones made by Mr. Bell, or his associates, under his patents, were in public and commercial use at the dates which I will indicate.

*Ans.* By June 30, 1877, about 164 hand, and 70 box telephones were in public use.

By July 31, 1877, about 658 hand, and 120 box telephones were in public use.

By Aug. 31, 1877, about 1,000 hand, and 300 box telephones were in public use, all of which had metallic diaphragms of soft iron.

By Oct. 31, 1877, about 3,000 telephones in all were in use.

By June 1, 1879, over 33,000 were in use.

*Cross Examination by* W. D. BALDWIN, Esq., *of Counsel for Gray.*

*Cross-Int.* 32. Please point out any portion of Bell's patent of March 7, 1876, which in term specifies an electric speaking telephone.

*Ans.* I cannot find that the patent mentioned uses that term.

[*Adjourned.*]

MARCH 11.

*Direct Examination resumed, by* Mr. STORROW, *of counsel for Bell.*

*Int.* 33. Please state whether or not said patent states and shows an apparatus by which the same vocal sound that is uttered into the transmitter by the human voice is heard to proceed from the receiver without any limitation as to the character of the sound.

*Ans.* It certainly does.

*Int.* 34. Please state, as to the early telephones put out in April and May, 1877, whether written leases for them were executed at the time the instruments were furnished and put up, or whether the leases were executed subsequently; and state, if you recollect, the earliest date when any such leases were executed.

*Ans.* The leases were invariably executed from a week to a

month later than the date of putting the instruments in use. The date of the first lease that was executed for telephones was June 8, 1877.

*Cross Examination by* L. W. SERRELL, Esq., *of Counsel for Edison*

*Cross-Int.* 35. Please refer to the drawing marked "Exhibit No. 37, Bell's Toronto Drawing," and state at what time the instrument shown in the lower right-hand figure was first employed in the manner indicated in the writing under that figure.

*Ans.* Some time during June or July, 1875. Certainly not later than the middle of July, 1875.

*Cross-Int.* 36. Please refer to p. 71 of Prescott's work on the Speaking Telephone, etc., 1879, and state whether or not the account given of the instrument, Fig. 49, corresponding with the sketch last referred to, is correct.

*Ans.* I do not consider that it is correct.

*Cross-Int.* 37. It appears to have been a statement made by Mr. Bell in his lecture before the Society of Telegraphic Engineers, Oct. 31, 1877. Do you now think that your recollection of the operation of that instrument is more correct than the statements of Mr. Bell given over three years ago?

*Ans.* I do.

*Cross-Int.* 38. Wherein was Mr. Bell's statement then given incorrect, and when did you first find out that it was incorrect?

[*Question objected to, for the reason that it is a matter which the examining counsel should have examined Mr. Bell upon if he desired the information. Counsel for Mr. Edison replies that he had no reason to suppose his statements made at his lecture were incorrect, or else he should have asked Mr. Bell upon the subject.*

*Counsel for Bell objects to remarks of counsel for Edison as improper to go upon the record, and because the subject having been fully gone into on Mr. Bell's examination, counsel refrained from cross-examining him.*]

*Ans.* The results were entirely satisfactory to both of us, and Mr. Bell was greatly encouraged by the result of the experiment. I discovered that it was incorrect when I first read the lecture, about a month or two after it was delivered.

*Cross-Int.* 39. Did you call Mr. Bell's attention, and if so, when, to the incorrectness of the statements he had made?

*Ans.* I think I did, immediately on his return from England, in the winter of 1878-9.

*Cross-Int.* 40. Please refer to Fig. 7 of Bell's first patent, No. 174,465, and state whether or not the instrument therein represented is the same one as that shown in Fig. 49 of Prescott's work before spoken of, and mentioned in Mr. Bell's lecture before the Society of Engineers.

[*Objected to on the ground that the figures speak for themselves.*]

*Ans.* Each of the figures referred to shows two telephones. The left-hand one of those in Fig. 7 of the patent is substantially the same as either of those shown in Fig. 49 of Prescott's book. The right-hand instrument of Fig. 7 of the patent differs substantially in the shape of the mouthpiece.

*Cross-Int.* 41. About how many instruments did Mr. Bell make with a membrane diaphragm, an electro-magnet and a hinged armature upon one pole of the magnet connected with the diaphragm similar to those shown in the figures referred to, regardless of the shape of the mouthpiece, before the end of 1877?

*Ans.* At least two.

*Cross-Int.* 42. Did Mr. Bell use, in connection with those instruments, mouthpieces in either of the forms shown in the drawings before referred to?

*Ans.* The mouthpieces, as I remember them, were similar to those shown in Fig. 7 of the patent. The instruments were constructed in such a manner that different shapes of mouthpieces could be attached.

*Cross-Int.* 43. Are you confident that such tubes or mouthpieces were used with these instruments?

*Ans.* I am.

*Cross-Int.* 44. Please refer to the drawing of the instrument Exhibit 40, after p. 75, Vol. II., of the Dowd case, and also to Figs. 51 and 59, pp. 72 and 93 of Prescott's Speaking Telephone, and state whether or not those three figures are intended to represent the same instrument.

*Ans.* Figs. 51 and 59 of Prescott's work represent the same in-

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strument, but the drawing Exhibit 40 represents a different instrument.

*Cross-Int.* 45. How many instruments like Exhibit 40 were made prior to the end of 1877?

*Ans.* I only remember one exactly like this figure.

*Cross-Int.* 46. What kind of a metal plate was used on the top of that instrument; and how was it fastened?

*Ans.* The metal plate was made of soft iron, about the same diameter as the top of the tube, and about two one hundredths of an inch thick, and the instrument was generally used with the plate laid on the top of the tube, and held there by the attraction of the magnet. We sometimes used a wooden mouthpiece, which fitted on the top of the tube and pressed upon the edge of the diaphragm. The wooden mouthpiece was used during October or November, 1876.

*Cross-Int.* 47. When was any instrument made with the plate fastened at one edge to the tube, and standing up at the opposite edge from the tube, as represented at Figs. 51 and 59 of Prescott's work, before referred to?

*Ans.* The first instrument of this kind that had the screw through the edge of the diaphragm was the one given to Sir Wm. Thomson, in the summer of 1876. The office of the screw was merely to prevent the diaphragm from being lost.

*Cross-Int.* 48. When the screw was tightened did not the opposite edge of the disk or diaphragm rise above the top of the tube?

*Ans.* I am very certain that it did not.

*Cross-Int.* 49. Do you know who furnished the drawings of these instruments that have been put in Mr. Prescott's said work as being part of Mr. Bell's London lecture?

*Ans.* I do not.

*Cross-Int.* 50. How many instruments substantially like Fig. 51, in Prescott's work, were made before the end of 1877?

*Ans.* I perfectly remember three.

*Cross-Int.* 51. On about how many occasions during 1876 was an instrument made use of corresponding to Fig. 7 of the Bell patent No. 174,465?

*Ans.* Such an instrument was used constantly during the experiments

*Ans.* As nearly as I can remember, one or two months.

*Cross-Int.* 65. About how many telephones has the Bell Company now in operation in the different cities and places under its license; and what proportion of those instruments are in circuits provided with batteries, and what proportion without batteries?

*Ans.* The Bell Company has about 150,000 telephones in use under its license in the United States, of which about 60,000 have batteries used in connection with them; the rest are magneto-telephones which are not provided with batteries.

*Cross-Int.* 66. About how many magneto-telephones are in use upon circuits in which batteries are provided for use when desired?

*Ans.* About 90,000.

*Cross-Int.* 67. About how many magneto-telephones are in use upon circuits in which batteries are not provided at all, directly or indirectly?

*Ans.* Somewhat more than 25,000.

*Cross-Int.* 68. Is it not a fact that in cities where there are numerous lines adjacent to telephone lines that the magneto-telephone without any battery in the circuit is very liable to indicate false sounds?

*Ans.* No more so than with a battery.

*Cross-Int.* 69. Is it not a fact that in instances where a carbon transmitter and a battery are made use of under the circumstances required in the last question, the sounds are much more clear and distinct than they are when a magneto transmitter is made use of?

*Ans.* The carbon or battery transmitter of any kind will undoubtedly transmit sound more loudly than a magneto transmitter; but either could be and is used under the circumstances described in Cross-Int. 68.

*Cross-Int.* 70. Is it not a fact that telephone instruments in which batteries and carbon, or similar transmitters, are employed, are less liable to detrimental influences by inductive currents than the magneto instruments?

*Ans.* The only effect of inductive currents on a telephone circuit that would be detrimental to its working, is the noise produced by such currents in the receiving telephones connected with such circuit

This noise would be no greater if a magneto-telephone was used as a transmitter than if a battery transmitter was used.

*Cross-Int.* 71. When a battery transmitter is used under the circumstances spoken about in your last answer; do the noises interfere with the reception of the message as much as they do when a magneto transmitter is used?

*Ans.* They do not.

*Cross-Int.* 72. And is that the reason why the battery transmitters have been as extensively used as indicated in your previous evidence?

*Ans.* That is one reason.

*Cross-Int.* 73. Have you made any careful experiments by which to ascertain the comparative merits of the Edison carbon transmitter and the Blake carbon transmitter; taking into account the reliability of the adjustment, the tendency to change under different atmospheric conditions, the quality of the articulation at the receiving instrument and the relative cost of construction?

*Ans.* I have made many such experiments and am familiar with the relative cost.

*Cross-Int.* 74. Is it not a fact that in the Blake transmitter the electrodes are liable to separate where a loud talking or shouting takes place at the instrument?

*Ans.* This is a defect common to all battery transmitters, and the Blake transmitter is no more affected that way than any other.

*Cross-Int.* 75. Do you know whether in the Edison carbon transmitter the electrodes will separate under the circumstances inquired of in the last question?

*Ans.* It will, under certain adjustments.

*Cross-Int.* 76. Please answer my previous question under the supposition that the Edison instrument is adjusted in the most approved manner by a competent person.

*Ans.* The most approved method of adjusting an Edison transmitter is undoubtedly to make the pressure of one electrode against another so great that it would not separate under the influence of shouting. This necessitates placing the lips close to the mouthpiece when talking to it. In practice this is inconvenient, and the transmitter is often adjusted with the electrodes pressing less tightly, so

that the lips need not be placed so closely to the mouthpiece. Under the latter adjustment the electrodes would separate if spoken to loudly with the lips touching.

*Cross-Int.* 77. Have you ever known of any instance where the electrodes in the Blake transmitter have been injured by an electric spark passing when the electrodes were separated?

*Ans.* I have never known an instance of the Blake transmitter being injured that I have traced to this cause.

*Cross-Int.* 78. Has the Bell Company ever manufactured the Edison carbon transmitter themselves; and if so, to what extent?

*Ans.* The Bell Company do no manufacturing whatever. The Bell Company have ordered about five hundred from the Western Electric Manufacturing Company since November, 1879. These were ordered shortly after the Bell Company obtained control of the Edison patents.

*Cross-Int.* 79. Is it not a fact that the Bell Company now has the entire control of the telephone business so far as the Edison, Blake, Bell and Gray inventions are concerned; and can supply whichever instrument they see fit to their customers?

*Ans.* It is a fact that the Bell Company has such control; but it has to supply such telephones as are called for by its agents.

*Cross-Int.* 80. About how many Edison carbon transmitters were turned over to the Bell Company at the time of the consolidation in November, 1879?

*Ans.* Between 1,500 and 20,000.

*Cross-Int.* 81. And about how many of them are now in use?

*Ans.* I should judge about one half that number.

*Cross-Int.* 82. Is the article in the *Scientific American*, Sept. 9, 1876, a correct statement of the extent of success obtained by Mr. Bell at that time?

*Ans.* It is, I think, substantially correct. The first part of it refers to experiments made several months previous.

*Cross-Int.* 83. In the trial of the telephone for articulate speech on a telegraph line, which was stated was on the 9th of October, 1876, referred to in your answer to int. 14, what kind of instruments were made use of?

*Ans.* Both instruments used in the experiment described in the

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article from the *Boston Advertiser* of Oct. 9, 1876, were substantially the same as complainants' Exhibit No. 38, Bell's Single Pole Centennial Membrane Telephone, following p. 75 of the Dowd suit, Vol. II. But the mouthpieces were omitted.

*Cross-Int.* 84. Were the instruments made use of in the trial between New York and Boston, April, 1877, at both ends alike? And state whether or not any battery was used on the line.

*Ans.* They were substantially alike, and no battery was used.

*Cross-Int.* 85. State whether or not the magnet was adjustable.

*Ans.* It was.

*Cross-Int.* 86. And in what respect was it similar to the magnet shown in Bell's patent of Jan. 30, 1877, No. 186,787?

*Ans.* It had precisely the same adjustment as that shown in Figs. 2 and 3, but had a horseshoe magnet instead of a bar magnet.

*Cross-Int.* 87. When first did Mr. Bell make use of an iron diaphragm?

*Ans.* One of the telephones exhibited at the Centennial, in July, 1876, was the first instrument I know of that had an iron diaphragm.

*Cross-Int.* 88. When first did Mr. Bell make use of an iron diaphragm with a case or mouthpiece intervening between the diaphragm and the mouth of the speaker or the ear of the listener?

*Ans.* In August, 1876.

*Cross-Int.* 89. Please refer to the instrument shown in Figs. 2 and 3 of Bell's patent, No. 186,787, and state when first such an instrument was made.

*Ans.* It was made about the middle of October, 1876.

*Cross-Int.* 90. To what extent have instruments like those shown in the said figures of the patent been made or used?

*Ans.* I consider that all the magneto-telephones that the Bell Company has in use are substantially like the telephones shown in Figs. 2 and 3 of that patent, the difference being chiefly in the case and shape of the mouthpiece. Not over a dozen telephones exactly like those shown have ever been manufactured.

*Cross-Int.* 91. So far as the rights of the Bell Company relate to the invention of Mr. Bell, as now made use of by the company, is there any other patent or application of Mr. Bell, other than the two

patents now in interference, which shows any device or invention of Mr. Bell?

*Ans.* There are at least two other patents that I have in mind of Mr. Bell's, that relate to speaking telephones that are the property of the Bell Company, one of them, No. 228,507, June 8, 1880. The subject matter of that patent is not now made use of by the company practically.

Another, No. 220,791, Oct. 21, 1879, is made use of to a limited extent.

Another, No. 213,090, March 11, 1879, which is not used practically by the company.

Another, No. 201,488, March 19, 1878, which is not used practically by the company.

*Cross Examination by* GEO. W. DYER, Esq., *of Counsel for Voelker.*

*Cross-Int.* 92. In July, 1879, I suppose that you had gone to a pretty large extent into the manufacture of telephones, and had abundant machinery and skilled workmen in your employ; and at that time had acquired a good deal of skill in the construction and the manipulation of telephones?

*Ans.* Nearly all the telephones that the Bell Company have in use have been made by contract with Chas. Williams, Jr., Boston. The workmen who make them are consequently in his employ. I consider that I was well posted at that time in all the mechanical and electrical branches of the telephone business.

*Cross Int.* 93. What connection had you with the works of Williams?

*Ans.* I have no direct connection with Mr. Williams's works, but my duties as general inspector and engineer of the telephone company, necessitate my spending considerable time at his works. I am and have been entirely in the employ of the owners of the Bell patents since August or September, 1876.

*Cross Int.* 94. Since that time, have the telephone instruments been made under your direction and inspection, or either direction or inspection?

*Ans.* They have been made almost entirely under my direction and

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inspection. I have and have had assistant inspectors, whose duties are to examine details.

*Cross-Int.* 95. Have you determined forms, sizes and arrangement of parts in the telephones made under your direction at Williams's works?

*Ans.* I have, to a great extent.

*Cross-Int.* 96. What other person has to any less extent?

*Ans.* Mr. Francis Blake, the inventor of the Blake transmitter, and Mr. Emilie Berliner, have suggested sizes, and forms of details to a certain extent; and I have accepted their suggestions. This applies merely to the manufacture of telephones, and not to their invention.

*Cross-Int.* 97. Have you determined materials, as well as forms, etc.?

*Ans.* Almost entirely, where there has been any choice of materials.

*Cross-Int.* 98. In the summer of 1879 had you the skill and experience which would enable you to manufacture a telephone capable of use in transmitting and receiving articulate speech, if such capacity had existed in the invention of that telephone?

*Ans.* In the summer of 1879 I had sufficient skill and experience to make any form of speaking telephone, as well as any other man I know of.

*Cross-Int.* 99. In the experiments related by you in your testimony in the summer of 1879, with instruments wholly reproduced, or reproduced in large measure, did you bring to bear your best skill in the manipulation of such instruments?

*Ans.* I do not think I did. I did not make the instruments at all; merely examined them after they were made, and used them without any special adjustment as they came from the workmen's hand.

*Cross-Int.* 100. What was the purpose of the lectures and exhibitions stated by you in answer to Int. 10; covering the time from Jan. 13, 1877, up to May, 1877?

*Ans.* The only purposes that I know that Mr. Bell had in giving those lectures and exhibitions, were to raise money by admission fees, and to prove the practicability of the instrument.

*Cross-Int.* 101. Referring to that part of your answer to Int. 20,

relating to putting telephones on a line for Stone & Downer, do you know upon what terms or conditions telephones were put up on that line?

*Ans.* They were to be paid for at our regular rates, if satisfactory; and they were, I think, afterwards paid for.

*Cross-Int.* 102. Do you know how long after?

*Ans.* I think it was several months, but as I have had nothing to do with the financial branches of the telephone company's business, it will be impossible for me to say without reference to their books.

*Cross-Int.* 103. Were the telephones on that line changed during their use by Stone & Downer?

*Ans.* They were. It was the custom of the company to exchange telephones, when improvements of any importance were made. That custom has continued to the present day.

*Cross-Int.* 104. Was that change made before Stone & Downer paid?

*Ans.* I cannot positively say, but I think not.

*Cross Int.* 105. Were the terms of compensation by Stone & Downer, in accordance with the circular of Mr. Gardiner G. Hubbard, set out in full in your deposition?

*Ans.* I think they were, substantially.

*Cross-Int.* 106. When were the telephones put on the line between the offices of the Board of Water Works at Cambridge?

*Ans.* In May, 1877, shortly after the publication of the articles in the Boston *Herald* and Boston *Advertiser* of May 19, 1877, which are given in my testimony.

*Cross-Int.* 107. Do you know upon what terms or conditions these telephones were furnished?

*Ans.* They were to be paid for, if satisfactory, at our regular rates, substantially as stated in the circular already mentioned.

*Cross-Int.* 108. Do you know who furnished this article to the Boston *Daily Advertiser* of May 19, 1877, or the material for it?

*Ans.* I do not.

*Cross-Int.* 109. Were the telephones put up on the line to Professor Holmes's connecting with Brewster, Bassett & Co.'s bank, put

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up on the same conditions as those just mentioned, of Stone & Downer and the Cambridge Water Works?

*Ans.* No. Under the arrangement we had made or were about to make with Mr. Holmes, he was to have the right to place telephones on the lines connecting his central office with the various banks throughout the city of Boston; Mr. Holmes was to pay us a rental of $10 for each telephone per annum, he collecting a larger sum than that from the banks for the use of the telephone and line and services rendered in connecting one bank with the other as they might desire. The title of Professor is erroneously applied to Mr. Holmes. He was the general manager of the Holmes Burglar Alarm Telegraph Company, and he was to use the telephones on his line wires.

*Cross-Int.* 110. Was he to pay for those telephones whether they were satisfactory or not?

*Ans.* He satisfied himself of the practicability of the telephone before beginning negotiations with the owners of the Bell patents, as the introduction of the telephones on his burglar alarm wires necessitated quite an expense for alterations, which expense he met; and I think the first telephones he had, he expected to pay for; but, had they not been satisfactory, we should certainly not have asked for pay any more than from the preceding gentlemen.

*Cross-Int.* 111. What was the first instance when telephones were furnished for commercial use without conditions?

*Ans.* It was our practice, during nearly the whole of 1877, to allow agents to put out telephones and let their customers try them for a few weeks, before requiring payment, giving them the right to return if unsatisfactory. The chief reason why we did this was the great doubt that existed in everybody's mind, when first approached to leave a telephone, as to whether it was possible to do such a wonderful thing as to transmit articulate speech over a telegraph wire. As this doubt wore off, we began to require payment as soon as the telephones were put in working condition. At the present time we would not require any customer to keep a telephone that he was not satisfied with. The first lease that was executed and payment made for telephones was, as I have already testified, dated June 8, 1877.

These instruments were put into use about one week previous to that time.

THOMAS A. WATSON.

MARCH 11, 1881.

Subscribed and sworn to before me,

CHARLES H. SWAN, *U. S. Commissioner.*

# Circuit Court of the United States,

## DISTRICT OF MASSACHUSETTS.

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**No. 1424.**

AMERICAN BELL TELEPHONE COMPANY ET AL.

*v.*

ALBERT SPENCER ET AL.

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## OPINION OF THE COURT.

[JUNE 27, 1881.]

LOWELL, J.

The bill alleges an infringement of two patents, granted to Alexander Graham Bell. The defendants admit that they have infringed some valid claims of the second patent, but the plaintiffs are not content with this admission; they rely besides upon the fifth claim of the first patent, which is much more comprehensive in its scope.

Patent No. 174,465, issued to Bell, dated March 7, 1876, is entitled "Improvement in Telegraphy," and is said in the specification to consist in "the employment of a vibratory, or undulatory current of electricity in contradistinction to a merely intermittent or pulsatory current, and of a method of and apparatus for producing electrical undulations upon the line wire." The patentee mentions several advantages which may be derived by the use of this undulatory current, instead of the intermittent current, which continually makes and breaks contact, in its application to multiple telegraphy, that is, sending several messages, or strains of music, at once over the

same wire; and the possibility of conveying sounds, other than musical notes. This latter application is not the most prominent in the specification; though, as often happens, it has proved to be of surpassing value. This part of the invention is shown in figure 7, of the drawings, and is thus described in the text:

"The armature, *c*, Fig. 7, is fastened loosely by one extremity to the uncovered leg, *d*, of the electro-magnet, *b*, and its other extremity is attached to the centre of a stretched membrane, *a*. A cone, A, is used to convey sound vibrations upon the membrane. When a sound is uttered in the cone, the membrane, *a*, is set in vibration, the armature, *c*, is forced to partake of the motion, and thus electrical undulations are created upon the circuit *E*, *b*, *e*, *f*, *g*. These undulations are similar in form to the air vibrations caused by the sound; that is, they are represented graphically by similar curves. The undulatory current passing through the electro-magnet, *f*, influences its armature, *h*, to copy the motions of the armature, *c*. A similar sound to that uttered in A, is then heard to proceed from L."

With the figure 7 before us, this description is readily understood. A cone of pasteboard, or other suitable material, has a membrane stretched over its smaller end; at a little distance is a piece of iron magnetized by a coil through which is passing a current of electricity. When sounds are made at the mouth of cone, A, the membrane vibrates like the drum of a human ear; and the armature, which is directly in front of the magnet, vibrates with the membrane, and its movements cause pulsations of electricity like those of the air which excited the membrane, to pass over the wire; and the wire stretches to another similar magnet and cone with its membrane and armature. The second armature and membrane take up the vibrations and make them audible by repeating them into the condensing cone, L, which translates them into vibrations of the air.

The defendants insist that the instrument represented in

figure 7 will not transmit articulate speech; that this great result has been reached by Mr. Bell entirely through the improvements described in his second patent, such as the substitution of a metal plate for the stretched membrane, and some others.

The importance of the point is, that if Bell, who is admitted in this case to be the original and first inventor of any mode of transmitting speech, had not completed his method, and put it into a working form when he took his first patent, he may lose the benefit of his invention; because, in his second patent, he makes no broad claim to the method or process, but only to the improvements upon a process assumed to have been sufficiently described in his first patent.

There is some evidence that Bell's experiments with the instrument, described in figure 7, before he took out his patent, were not entirely successful; but this is now immaterial; for it is proved that the instrument will do the work, whether the inventor knew it or not, and in the mode pointed out by the specification.

The fifth claim of this patent is for

"The method and apparatus for transmitting vocal, or other sounds, telegraphically, by causing electrical undulations, similar in form to the vibrations of the air accompanying the said vocal, or other sounds, substantially as set forth."

The defendants use a method and apparatus for transmitting vocal sounds, which resemble those of the plaintiffs in producing electrical undulations copied from the vibrations of a diaphragm, and sending them along a wire to a similar receiver at the other end. The specific method of producing the electrical undulations is different. It is made on the principle of the microphone, which has been very much improved since the date of the first Bell patent.

If the Bell patent were for a mere arrangement, or combination of old devices, to produce a somewhat better result in

a known art, then, no doubt, a person who substituted a new element not known at the date of the patent might escape the charge of infringement. But Bell discovered a new art, — that of transmitting speech by electricity, — and has a right to hold the broadest claim for it which can be permitted in any case; not to the abstract right of sending sounds by telegraph, without any regard to means, but to all means and processes which he has both invented and claimed.

The invention is nothing less than the transfer to a wire of electrical vibrations like those which a sound has produced in the air. The claim is not so broad as the invention. It was, undoubtedly, drawn somewhat carefully in view of the decision in *O'Reilly* v. *Morse*, 15 How. 62, and covers the method and apparatus, that is, any process and any apparatus of substantially similar character to those described. The patent points out distinctly, that the undulations may be produced in other modes besides the vibration of an armature in front of a magnet; and the defendants make use of a mode not wholly unknown at that time, though much improved, in creating their undulations.

It seems to me that the defendants use both the method and the apparatus of Bell. The essential elements of the method are the production of what the patent calls undulatory vibrations of electricity to correspond with those of the air, and transmitting them to a receiving instrument capable of echoing them. Granting that the defendants' instrument for converting the vibrations of the diaphragm into vibrations of electricity is an improvement upon that of the plaintiffs, still it does the same sort of work, and does it in a mode not wholly unknown at the date of the patent; though I do not consider that material.

An apparatus made by Reis, of Germany, in 1860, and described in several publications before 1876, is relied on to

limit the scope of Bell's invention. Reis appears to have been a man of learning and ingenuity. He used a membrane and electrodes for transmitting sounds, and his apparatus was well known to curious inquirers. The regret of all its admirers was, that articulate speech could not be sent and received by it. The deficiency was inherent in the principle of the machine. It can transmit electrical waves along a wire, under very favorable circumstances, not in the mode intended by the inventor, but one suggested by Bell's discovery, but it cannot transmute them into articulate sounds at the other end, because it is constucted on a false theory, and the delicacy of use required to make it perform part of the operation is fatal to its possible performance of the other part. A Bell receiver must be used to gather up the sound before the instrument can even now be adapted to a limited practical use. It was like those deaf and dumb pupils of Professor Bell, who could be taught to speak, but not to hear. That was all, but it was enough. A century of Reis would never have produced a speaking telephone by mere improvement in construction.

I am of opinion that the fifth claim of patent No. 174,465, is valid, and has been infringed.

The statute declares that if a patentee has claimed too much in any part of his patent he shall not recover costs, and it has been argued that certain claims of these patents, not relied on by the plaintiffs, are too broad. In this stage of the case the question of costs does not arise; but I may as well say, that there is not sufficient evidence in the record to enable me to find whether these claims are valid or not; and that the statute does not mean that claims not in issue should be contested for the mere purpose of settling the costs. More expense might be incurred in such a mode of trial than depended upon the main issue.

*Decree for the complainants.*

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# CIRCUIT COURT OF THE UNITED STATES.

DISTRICT OF MASSACHUSETTS.

IN EQUITY.

AMERICAN BELL TELEPHONE COMPANY ET AL.

*v.*

ALBERT L. SPENCER ET AL.

## DECREE.

This cause came on to be heard upon the bill, answer, replication and proofs, and was argued by counsel and considered by the Court whereupon it is now, to wit, Aug. 27, 1881, ordered, adjudged and decreed that Alexander Graham Bell is the original and first inventor of the invention specified in the fifth claim of the patent numbered 174,465, granted to said Bell March 7, A. D. 1876, and the fifth, sixth and eighth claims of the patent numbered 186,787, granted to said Bell Jan. 30, 1877, being the claims in respect of which the proofs were taken; that the said patents are good and valid patents therefor; and the complainants waiving a reference to a master to ascertain profits and damages, and accepting nominal damages, it is further ordered that the defendants pay to the plaintiff the sum of one dollar as profits and damages, and also costs taxed at , and that they be perpetually enjoined from further infringing the said patents.

By the Court,

ALEX. H. TROWBRIDGE,
*Deputy Clerk.*

Attest: ALEX. H. TROWBRIDGE,
*Deputy Clerk.*

*At a stated Term of the Circuit Court of the United States in and for the Southern District of New York, held at the City of New York on the 7th day of December*, 1885.

Present: *The Honorable* WILLIAM J. WALLACE, *Circuit Judge*.

AMERICAN BELL TELEPHONE COMPANY *et al.*
*v.*
OVERLAND TELEPHONE COMPANY, ROBERT G. DUN, SYLVANUS C. BOYNTON, I. NEWTON EWELL, JOHN W. BARROW, ERATUS WIMAN, PETER P. POPE, JACOB MOESER, CHARLES P. CROSBY, AND SETH R. BECKWITH.

This cause came on to be heard at the October Term, 1885, of said Court, and was argued by counsel for the respective parties, and thereupon, and upon consideration thereof, it is found, and hereby ordered, adjudged, and decreed, that the several Letters Patent, upon which this suit is brought, viz., Letters Patent granted to Alexander Graham Bell, for an im-

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provement in telegraphy, dated March 7, 1876, and numbered No. 174,465; and Letters Patent granted to said Bell for an improvement in electric telegraph, numbered No. 186,787, and dated January 30th, 1877, are good and valid in law.

That the said Alexander Graham Bell was the original and first inventor of the inventions described in said several Letters Patent Nos. 174,465 and 186,787; that the title thereto, and to the inventions described and claimed therein, is vested in complainants, and that the defendants have infringed the fifth claim of said Letters Patent No. 174,465, and the third, fifth, sixth, seventh and eighth claims of said Letters Patent No. 186,787, and the exclusive rights of the complainants under the same.

And it is further ordered, adjudged and decreed, the complainants waiving an account and assessment of profits and damages, and accepting a nominal sum therefor, that the defendants pay to the complainants the sum of one dollar, as such profits and damages, and also costs taxed at the sum of fifteen hundred dollars, and that the complainants

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have judgment and execution therefor; and also that the said defendants and each of them, their and each of their clerks, attorneys, agents, servants, and workmen, and all others acting under or with them, be perpetually enjoined and restrained from making, selling, or using the said improvements, patented as aforesaid, or either or them, and that an injunction issue accordingly.

(sgd.) WM. J. WALLACE.

Defendant's Solicitor makes no objection to the form of the above decree.

(sgd.) CHAS. P. CROSBY,
*Solicitor for Defendants.*

(Endorsed): U. S. Circuit Court. Sourthern Dist. of N. Y. American Bell Telephone Co. & *al. v.* Overland Telephone Co. Decree. (file mark) U. S. Circuit Court. Filed Dec. 17, 1885.

TIMOTHY GRIFFITH,
*Clerk.*

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UNITED STATES CIRCUIT COURT.

SOUTHERN DISTRICT OF NEW YORK.

THE AMERICAN BELL TELEPHONE COMPANY *et al.*
*v.*
THE OVERLAND TELEPHONE COMPANY *et al.*
} IN EQUITY.

Whereas, in this cause sundry testimony has been taken, and also various records and parts of records from other suits and proceedings stipulated in, to stand as evidence in this cause as if originally taken herein;

Now it is agreed that the foregoing papers may constitute the record to be sent by the Clerk of the Circuit Court of the United States for the Southern District of New York to the Clerk of the Supreme Court of the United States on appeal to the said Supreme Court.

Whereas, the record in the suit of the American Bell Telephone Company *et al.* against the People's Telephone Company (commonly known as the Drawbaugh suit), and the record in the suit of the American Bell Telephone Company *et. al.* against the Molecular Telephone Company *et al.*, have been stipulated into this cause, to stand as evidence herein as if originally taken in this cause by the respective parties; and Whereas, an appeal has

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been taken in said Drawbaugh suit to the Supreme Court, and the record in the said suit of the American Bell Telephone Company *et al. v.* The Molecular Telephone Company *et al.* has been heretofore filed in the Supreme Court.

Now it is agreed, in order to save the expense of reprinting, that the parties to this cause and their counsel and the Court may refer to and use the printed copies of said records instead of reprinting them in this cause, with the same effect as if such records were herein actually filed, sent up and reprinted.

The foregoing stipulation is without prejudice to any motion hereafter to correct said record for errors in the transcript, if any such shall hereafter be found.

(Signed) JAMES J. STORROW,
*for Complts.*

(Signed) CHARLES P. CROSBY,
*for Defts.*

(Endorsed): U. S. Circuit Court. Filed, Oct. 11, 1886. Timothy Griffith, Clerk.

IN THE CIRCUIT COURT OF THE UNITED STATES.

FOR THE SOUTHERN DISTRICT OF NEW YORK.

THE AMERICAN BELL TELEPHONE COMPANY AND THE METROPOLITAN TELEPHONE AND TELEGRAPH COMPANY, *Complainants*,

*v.*

THE OVERLAND TELEPHONE COMPANY, ROBERT G. DUN, SYLVANUS C. BOYNTON, I. NEWTON EWELL, JOHN W. BARROW, ERASTUS WIMAN, PETER P. POPE, JACOB MOESER, CHAS. P. CROSBY AND SETH R. BECKWITH. *In Equity.*

*To the Honorable the Supreme Court of the United States:*

The Appeal of the above-named defendants and appellants respectfully showeth:

That on the twelfth day of April, in the year one thousand eight hundred and eighty three, the above-named complainants filed their Bill of Complaint in the Circuit Court of the United States, within and for the Southern District of New York, in Equity, against the above-named defendants,

wherein and whereby it was, amongst other things, prayed that the defendants might be decreed to account for and pay over to the complainants all such gains and profits resulting to them from the infringement mentioned in said Bill of Complaint, and might be restrained, together with their servants and agents, by an injunction to be issued out of this Court, or by one of its Judges, from making, selling, and using the improvements mentioned in said Bill of Complaint, and alleged in said Bill of Complaint to be patented, or either of them, and restrained, as aforesaid, during the pendency of this suit, and for such other or further relief in the premises as the nature of the case might require, and as to the Court should seem meet.

That a subpœna issued out of said Court was duly served on the said defendants and appellants; that the appearance of the defendants in said action was duly entered, and the answers of said defendants duly filed, and a replication to said answers was duly filed, and that the testimony in said action was taken before one of the proper officers of this Court appointed and qualified for that purpose.

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That on the seventeenth day of December, one thousand eight hundred and eighty-five, a final decree was entered in this action in favor of the Complainants and against the defendants, by which it was ordered, adjudged and decreed, amongst other things, that the several Letters Patent upon which this suit was brought, and which are more particularly mentioned in said final decree, are good and valid in law, and that the said Alexander Graham Bell, mentioned in the pleadings and proofs in this action, was the original and first inventor of the inventions described in certain Letters Patent particularly mentioned in said decree, and that the title thereto and to the inventions described and claimed therein is vested in the complainants, and that the defendants have infringed the fifth claim of the Letters Patent mentioned in said decree, number 174,465, and the third, fifth, sixth, seventh and eighth claims of said Letters Patent, number 186,787, and the exclusive rights of the Complainants under the same.

That it was by said decree further ordered, adjudged, and decreed, the complainants waiving an account and assessment of profits and damages and accepting a nominal sum therefor, that the *complain-*

*ants* pay to the *defendants* the sum of one dollar as such profits and damages, and also costs taxed at the sum of fifteen hundred dollars, and that the complainants have judgment and execution therefor; and also that the said defendants and each of them, their and each of their clerks, attorneys, agents, servants and workmen, and all others acting under or with them, be perpetually enjoined and restrained from making, selling or using said improvements patented as aforesaid, or either of them, and that an injunction issue accordingly.

Wherefore, these defendants and appellants appeal from the whole of said final decree of said Circuit Court of the United States for the Southern District of New York, in Equity, and respectfully pray that the decree of the said Circuit Court and the Bill, Answer, Pleadings, Depositions, Evidence and proceedings in the said cause may be sent to the Supreme Court of the United States without delay, and that the said Supreme Court of the United States will proceed to hear the said cause anew, and that the said decree of the said Circuit Court of the United States for the Southern District of New York, in Equity, and every part thereof may be reversed

and a decree made dismissing said Bill of Complaint with costs or such other decree as to the said Supreme Court shall seem just.

Dated December 24th, 1885.

(sgd.) THE OVERLAND TELEPHONE CO.,
*By* CHAS. P. CROSBY,
*Its Solicitor.*

ROBERT G. DUN,
SYLVANUS C. BOYNTON,
I. NEWTON EWELL,
JOHN W. BARROW,
ERASTUS WIMAN,
PETER P. POPE,
JACOB MOESER,
CHAS. P. CROSBY, *and*
SETH R. BECKWITH,
*By* CHAS. P. CROSBY,
*Their Solicitor.*

CHAS. P. CROSBY,
*Solicitor for Defendants and Appellants.*

The foregoing appeal is hereby allowed.

Dated the 4th day of January, 1886.

(sgd.) WM. J. WALLACE.

(Endorsed): United States Circuit Court. Southern District of New York. In Equity. The American Bell Telephone Company *et al.* Complainants and Respondents, against The Overland Tele- Company *et al.*

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Defendants and appellants. Claim of Appeal. Chas. P. Crosby, Solicitor for defendants. 160 Broadway, N. Y. City. Due and timely service of a copy of the within claim of appeal admitted this 6th day of January, 1886.

(Sgd.) DICKERSON & DICKERSON,
*Complainants' Solicitors.*
*No. 7 Beekman Street,*
*New York.*

(file mark)
U. S. Circuit Court. Filed Jan. 6, 1886.

TIMOTHY GRIFFITH,
*Clerk.*

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SUPREME COURT OF THE UNITED STATES.

THE AMERICAN BELL TELEPHONE COMPANY & THE METROPOLITAN TELEPHONE & TELEGRAPH COMPANY, *Complainants*,

*v.*

THE OVERLAND TELEPHONE COMPANY, ROBERT G. DUN, SYLVANUS C. BOYNTON, I. NEWTON EWELL, JOHN W. BARROW, ERASTUS WIMAN, PETER P. POPE, JACOB MOESER, CHAS. P. CROSBY, AND SETH R. BECKWITH, *Defendants*.

*Know all men by these Presents:*

That we, Robert G. Dun and Erastus Wiman, of the City, County and State of New York, are held and firmly bound unto the American Bell Telephone Company and the Metropolitan Telephone and Telegraph Company in the sum of three thousand dollars, to be paid to the said American Bell Telephone Company and the Metropolitan Telephone and Telegraph Company, its successors or assigns, to which payment, well and truly to be made,

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we bind ourselves, our and each of our heirs, executors and administrators firmly by these presents.

Sealed with our seals. Dated this twenty-fourth day of December, one thousand eight hundred and eighty-five.

Whereas, the above-named defendants have taken an appeal to the Supreme Court of the United States, to reverse the decree entered and rendered in the above-entitled action by the Circuit Court of the United States, within and for the Southern District of New York, or the Judge thereof.

Now, therefore, the condition of this obligation is such, that if the above-named defendants shall prosecute their said appeal to effect and answer all costs and damages, if they shall fail to make good their said appeal, then this obligation shall be void; otherwise the same shall be and remain in full force and virtue.

(sgd.) WM. CALDWELL. ROBERT G. DUN. [L. S.]
ERASTUS WIMAN. [L. S.]

UNITED STATES OF AMERICA.
SOUTHERN DISTRICT OF NEW YORK,
CITY AND COUNTY OF NEW YORK, ss.

Robert G. Dun, being duly sworn, says that he is worth the sum of six thousand dollars, over and above his just debts and liabilities.

(sgd.) ROBERT G. DUN.

Sworn to before me this 24th day of December, 1885.

(sgd.) WM. CALDWELL.
(No. 226.) *Notary Public N. Y. Co.*

UNITED STATES OF AMERICA.

SOUTHERN DISTRICT OF NEW YORK,
CITY AND COUNTY OF NEW YORK, ss.

Erastus Wiman, being duly sworn, says that he is worth the sum of six thousand dollars, over and above all his just debts and liabilities.

(sgd.) ERASTUS WIMAN.

Sworn to before me this 24th day of Dec., 1885.

(sgd.) WM. CALDWELL,
(No. 226.) *Notary Public N. Y. Co.*

We hereby assent to the approval of the foregoing bond.

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Dated, NEW YORK, Jan'y 2, 1886.

(sgd.) DICKERSON & DICKERSON.

It is agreed that a clerical error in the foregoing bond be corrected by writing in after the words "The Metropolitan Telephone and Telegraph Company," being folio 3 of the first page, the words" jointly, their respective," and striking out the word "its."

Dated, DECEMBER 29th, 1885.

(sgd.) ROBERT G. DUN.

(sgd.) ERASTUS WIMAN.

(Endorsed): Supreme Court of the United States. The American Bell Telephone Company *et al.*, complainants and Respondents, against The Overland Telephone Company *et al.*, Defendants and appellants. Bond on Appeal. Chas. P. Crosby, Solicitor for Defendants. 160 Broadway, N. Y. City.

U. S. Circuit Court. Filed Jan. 5, 1886.

TIMOTHY GRIFFITH,
*Clerk.*

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By the Honorable William J. Wallace, one of the Judges of the Circuit Court of the United States within and for the Southern District of New York.

*In Equity.*

*To The American Bell Telephone Company and The Metropolitan Telephone and Telegraph Company:*

Whereas, The Overland Telephone Company, Robert G. Dun, Sylvanus C. Boynton, I. Newton Ewell, John W. Barrow, Erastus Wiman, Peter P. Pope, Jacob Moeser, Charles P. Crosby, and Seth R. Beckwith, have lately appealed to the Supreme Court of the United States from a decree lately rendered in the Circuit Court of the United States within and for the Southern District of New York, in Equity, made in favor of you, the said American Bell Telephone Company and the Metropolitan Telephone and Telegraph Company, and have filed the security required by law.

You are therefore hereby cited to appear before the said Supreme Court of the United States at the City of Washington on the second Monday of October, 1886, to do and receive what may appertain to justice to be done in the premises.

Dated JANUARY 5th, 1886.

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(sgd.) WM. J. WALLACE,
*Circuit Judge.*

(Endorsed): Supreme Court of the United States. The American Bell Telephone Company *et al.*, Complainants and Respondents, against The Overland Telephone Company *et al.*, Defendants and Appellants. Citation. Chas. P. Crosby, Solicitor for Defendants. 160 Broadway, N. Y. City.

Due and timely service of a copy of the within Citation admitted this 6th day of January, 1886.

(sgd.) DICKERSON & DICKERSON,
*Complainants' Solicitors.*
*No. 7 Beekman Street,*
*New York.*

(File mark.) U. S. Circuit Court. Filed Jan. 6, 1886.

TIMOTHY GRIFFITH,
*Clerk.*

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UNITED STATES OF AMERICA,
SOUTHERN DISTRICT OF NEW YORK, ss.

I, Timothy Griffith, Clerk of the Circuit Court of the United States of America, for the Southern District of New York, in the Second Circuit, do hereby certify that the foregoing pages, numbered from One to Four thousand one hundred and ninety-three (4193), inclusive, contain a true and complete transcript of the record and proceedings had in said Court, in the case of The American Bell Telephone Company *et al.* against The Overland Telephone Company *et als.*, as the same remains of record and on file in said office.

In testimony whereof, I have caused the seal of the said Court to be hereunto affixed, at the City of New York, in the Southern District of New York, in the Second Circuit, this fourteenth day of October, in the year of our Lord one thousand eight hundred and eighty-six, and of the Independence of the said United States the one hundred and eleventh.

(Sgd.) TIMOTHY GRIFFITH,
*Clerk.*

{ Seal of C. C. U. S., So. Dist. N. Y. }

(Endorsed on cover): S. New York, C. C. U. S. No. 1165. The Overland Telephone Company, Robert G. Dun, Sylvanus C. Boynton, J. Newton Ewell, John W. Barrow, Erastus Wiman, Peter P. Pope, Jacob Moeser, Charles P. Crosby, and Seth R. Beckwith, Appellants, *v.* The American Bell Teldphone Company and The Metropolitan Telephone and Telegraph Company. Filed October, 15, 1886.